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A STUDY ON ANG-KAK AND ITS PRODUCTION

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SIX PLATES AND ONE TEXT FIGURE

Ang-kak[1] is produced by growing on rice a mold known as *Monascus purpureus* Went. According to Church(3) the strains of *M. purpureus* which are adapted to the production of red rice are only those that are capable of impregnating rice with a dark red color in the presence of water sufficiently low as to prevent distortion of plumpness of the grains. According to Nishikawa(9) the dark red color consists of two pigments, the red, monascorubrin ($C_{22}H_{24}O_5$) and the yellow, monascoflavin ($C_{17}H_{22}O_4$). Gibbs and Agcaoili(5) state that it is locally prepared by soaking rice in solutions of certain wood dye and then drying it. These authors were apparently less up-to-date in their literature on the nature of ang-kak and the process of its manufacture.

The manufacture of ang-kak according to Church(3) is known only to the Chinese in certain localities in China and since they have been very secretive about it, the know-how of the process has not spread to many other parts of that country. If this is true, there is ground for believing that the ang-kak sold in the Philippines came from China and not manufactured here.

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[1] Ang-kak is variously known in literature as red rice, Chinese red rice, ang-khak, ankak, anka, ang-quac, beni-koji, and aga-koji.

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Ang-kak is used in the Philippines for coloring *bagoong*[2] and *atsike*[3] and for imparting flavor and attractive color to *burong isda*[4] and some other foods. Its use as a coloring agent is known to bagoong manufacturers even perhaps before the close of the last century. The senior author remembers that as a child of eight to ten (1907–1909) he often ground ang-kak in a mortar for his mother who learned to use it for coloring bagoong when she was a young woman.

Church(3) states that the special use of this rice product is for coloring Chinese cheese and for making a Chinese drink known as *anchu* in Formosa. Hisieh(7) reports that the ang-kak fungus which he calls "reddish yeast" is used for brewing *hung-chu* or red wine. According to Young(15) the ang-kak in the form of cakes or ground grayish red powder is exported by the Chinese throughout Eastern Asia where it is used extensively in coloring fish and other foods and in the preparation of alcoholic drinks known as *anchu* and *samsu.*

There is no available record on yearly importation of ang-kak from China into the Philippines before and after the last world war. The importation of this product into the Philippines is believed to be still going on, as even at present when this country has no trade relation with the mainland of China, it can be obtained in limited quantities from the Manila markets. Perhaps it finds its way to the Philippines through the international port of Hongkong since there has not been any report on its manufacture in this country.

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[2] "Bagoong" is a salted fish commonly of *Stolephorus* spp., anchovy, (English) or dilis (Tagalog) or their fry known in Batangas Province, as dulong and *Sardinella fimbriata* (Cuv. and Val.), sardine or silinyasi (Tagalog) which has undergone fermentation and aging to which ang-kak solution in wine has been added to improve the color, aroma and flavor.

[3] *Atsike* is the Tagalog term for the salted roe of *Mugil* spp., mullet (English) or banak (Tagalog). According to Dr. E. A. Quisumbing, director, Philippine National Museum, the atsike sold in Mindoro, Batangas and Cavite provinces is sometimes reddened with ang-kak to make it attractive and appetizing. This observation was verified by Dr. D. V. Villadolid, formerly director, Bureau of Fisheries and presently, director, Biological Research Center, NIST.

[4] *Burong isda* is a salted fish, commonly murrel (English) or dalag (Tagalog), *Ophicephalus striatus* Bloch mixed with rice that has been fermented by the ang-kak fungus. Other species of fish, such as climbing perch or martiniko (Tagalog) *Anabas testudineus* (Bloch), pla-salit *Trichogaster pectoralis* (Regan) and bañgos *Chanos chanos* (Forskål) are also used.

This investigation was undertaken primarily to know the nature of the ang-kak, the important characteristics of the mold responsible for the formation of the red pigment and the essential requirements for its production from local rice varieties.

THE ANG-KAK MOLD

ORIGIN OF THE CULTURE

A sample of ang-kak was obtained from Divisoria Market, Manila. The grains were purplish Red (2.5 R 3/10)[5] and soft. Splitting the grains lengthwise or crosswise into halves, the red coloration was observed to penetrate into the inner tissues of nearly all of them. The powdered form was purplish Red (2.5 R 5/4).

A microscopic examination of a crushed grain in a drop of water showed the presence of numerous ascospores of the ang-kak fungus which were expelled from ruptured perithecia. A pour-plate dilution of the ascospores on Sabouraud's agar was made after determining that they were still viable. From an isolated vigorously-growing colony a pure culture was obtained and from it all of the subcultures used in all studies discussed hereunder were made.

MORPHOLOGICAL CHARACTERISTICS

Red color production.—An uncommon phenomenon that was constantly observed in a growing mycelium of the ang-kak fungus on potato-dextrose or Sabouraud's agar and which has not yet been described or reported in any of the available literature on ang-kak is the extrusion of the granular fluid through the tips of the hyphæ. This may be observed as early as 40 to 48 hours after planting the organism on the agar medium. At first only a few of the hyphæ may be observed extruding their granular contents but as the fungus grows and spreads on the agar more and more of them appear until the colony is profusely dotted with the extrudes from them (Plate 1, fig. 1). When the culture is still young the freshly extruded granular fluid is colorless, but after a few hours it gradually becomes tinged with shades of red, which finally passes over to reddish

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[5] Color nomenclature used in this paper is from Munsell Book of Color, Munsell Color Co., Baltimore, Md. (1929–1942). Citations of color according to Ridway's "Color Standard and Nomenclature" were not made in view of the unavailability of this book when this investigation was conducted.

Yellow-Red (2.5 YR 5/10) or Yellowish Red (7.5 R 5/10), respectively, in cultures on potato-dextrose or Sabouraud's agar.

The phenomenon of extrusion of the hyphal contents is best observed in hanging drop culture on potato-dextrose or Sabouraud's agar. The granular matter is expelled through the pore or through the ruptured wall at the tip of the hypha (Plate 1, fig. 2). The extrude sometimes aggregates at the tip of the hypha in the form of a guttatelike fluid (Plate 2, fig. 1) or of coherent irregularly-shaped mass which later ruptures spreading the granular particles (Plate 2, fig. 2) around the hyphal tip. There are instances, however, in which dispersion of the granular particles is effected with perhaps some force so that they are scattered over wider areas from the hyphal tip (Plate 3, fig. 1).

The production of the red-coloring matter is observed not only on the extruded granular fluid but also on the hyphal contents within. In old cultures on potato-dextrose or Sabouraud's agar the majority of the hyphæ contain the red coloring matter. It was observed also occasionally on the ascocarp and ascospores and on the granular particles of some conidia.

The coloring matter produced by the ang-kak fungus diffuses throughout the substratum. This is very apparent in slant cultures on Sabouraud's, potato-dextrose and Czapek's solution (3 per cent dextrose) agar. The discoloration of the agar below the mycelial growth may be observed in less than a week after planting the mold. From faint red, the color of the agar gradually becomes darker and darker until, in about a month, it approximates closely that of the mycelial growth.

Conidiophores and conidia formation.—The conidiophores arise from the submerged mycelium. In cultures on potato-dextrose agar they vary from 18 to 396 microns in length and from 3 to 5.4 microns in width. Shorter conidiophores are 0- to 1-septate; longer ones 2- to 6-septate. In young cultures they are colorless, in old ones many of them turn red. A conidiophore can be distinguished from the other filaments by the formation at its apex of the vesicular structure which is the conidium initial. As the vesicle enlarges a septum is laid below it separating the swollen structure from the conidiophore. Conidia are successively cut off by septation below the continuously elongating and swelling tip of the conidiophores forming chains usually of 3 to 6, rarely as many as ten units

(Fig. 1, *b*) and (Plate 3, fig. 2). There are instances in which the conidiophore, after producing a short chain of conidia, swerves its tip a little, continues to grow and produces another chain of conidia thus making the first chain appear as laterally formed.

The conidia which are spherical or slightly ovoid and generally colorless measure usually from 6 to 13 microns in diameter. With age a few of them show reddened granular contents. They are easily detached from the conidiophores. Cases of conidial vivipary were frequently observed on chains which are still attached to the conidiophores (Plate 4, fig. 1). Extrusion of granular fluid from germ tubes of viviparous conidia was occasionally observed, (Fig. 1, *a*).

Under favorable moisture and temperature conditions the mature conidia may germinate after 4 to 5 hours on agar medium producing one or more germ tubes (Fig. 1, *c*) which develop into a mycelium that produces reproductive structures which are predominantly ascosporic.

Perithecia.—The perithecia are regularly produced on all kinds of media in which fairly good growth is observed. They are formed in greater abundance when the organism is grown in media containing assimilable carbohydrates and an organic form of nitrogen. They are generally spherical in form with or without hyphal protuberances and with a casement of cuticularized hyphal walls (Plate 5, figs. 1 and 2). They are borne on septate or nonseptate stalks 9 to 100 or more microns long and measure from 24.7 to 47 microns in diameter from culture on rice (red rice) and 41.9 to 57.2 microns in diameter from culture on Sabouraud's agar. Encased by the cuticularized wall are ovoid ascospores which measure 4.4 to 6.6 microns long and 4 to 4.8 microns wide. On the average they are 5.5 microns long and 4.5 microns wide.

The pattern of perithecium formation on a hyphal branch (Fig. 1, *d*) suggests that it is sexually homothallic and is essentially the same as that described by Olive(10) for *Monascus purpureus* Went. Observations in hanging drop cultures on potato-dextrose or Sabouraud's agar show that two types of branches, the antheridial and ascogonial, are formed at the extremity of the hypha which is to become the stalk of the perithecium (Fig. 1, *d*). Fusion takes place between the tip of the ascogonial branch and the basal or middle part of the antheridial branch. The process of fertilization of the ascogonial cell has been very well studied by Olive(10) in his effort

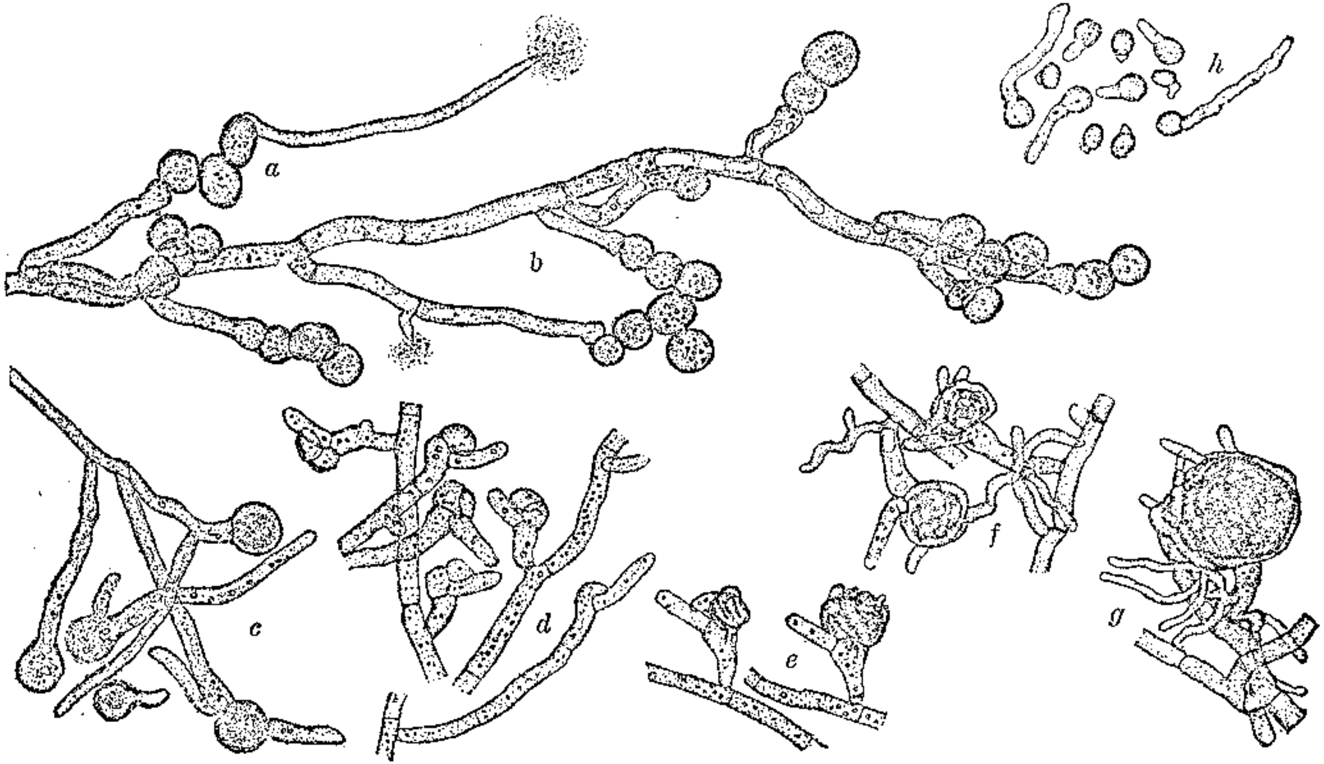

FIG. 1. Camera lucida drawings of *Monascus purpureus*, approximately. × 204; *a*, extrusion of granular fluid from the germ tube of a viviparous conidium; *b*, profuse formation of chains of conidia from a 2-day microslide culture on potato-dextrose agar; *c*, germinating conidia seen six hours after planting them on Sabouraud's agar in microslide culture; *d*, perithecium initials observed in microslide culture 48 hours after planting the ascospores on Sabouraud's agar; *e*, "invagination of the swollen central ascogonial cells"; *f–g*, young perithecia; *h*, germinating ascospores.

to clarify the points of difference between Barker(1) and Ikeno(8) regarding the morphology of *M. purpureus.* He describes the fusion between the tip portion of the ascogonial branch (trichogyne) and the basal cell of the antheridial branch to have taken place either before or after the wall is thrown across the tip of the ascogonium; that the swollen central cell is invaginated by "some body" which enters near the side on which the stalk is seen, enlarges and displaces the central cell; and that vacuolelike bodies develop preceding the final formation of ascospores (Fig. 1, *e*).

The more important phenomena connected with sexual reproduction of *M. purpureus* as described by Olive(10) appear to be essentially the same in principle as those portrayed by Schickorra,(11) Young,(16) and Gwynne-Vaughan(6) for genus *Monascus.* The difference seems to lie in the details of observation and interpretation.

CULTURAL CHARACTERISTICS

On Sabouraud's agar.—Colonies (Plate 6, fig. 1) growing rapidly attaining an average diameter of 6.2 centimeters in ten days at room temperature (29 to 32°C), circular, producing yellowish Red (7.5 R 5/10)) close-textured basal mat of submerged mycelium from which arise a loose superficial growth of hyphæ bearing the perithecial and conidial structures and an overgrowth of cobwebby sterile filaments, becoming slightly zonate with age; reverse in deeper red shade; perithecia, fairly abundant; conidiophores thinly distributed, many shedding their conidia in older cultures.

On potato-dextrose agar.—Colonies (Plate 6, fig. 2) growing fairly well at room temperature (29 to 32°C) spreading irregularly reddish Yellow-Red (2.5 R 5/10) with central and submarginal areas densely covered with perithecial and conidial structures and an overgrowth of sterile filaments, showing a tendency to develop sectors; surface at the middle area becoming wrinkled with age; reverse in Red Yellow-Red (10.0 R 5/10); perithecia, stalked, abundant; conidiophores fairly abundant, many shedding conidia.

On Czapek's solution agar (3 per cent dextrose).—Colonies (Plate 6, fig. 3, left) rather restricted to fair in growth, attaining a diameter of 1.8 to 2.6 centimeters after 10 days at room temperature (29 to 32°C), largely submerged, spreading irregularly, with central areas becoming a close-textured mat of abnormally swollen closely-septate hyphal cells and conspicuously raised forming cavities at points of inoculation, yellowish Red (7.5 R 5/10); perithecia fairly abundant.

On Czapek's solution agar (3 per cent sucrose).—Colonies (Plate 6, fig. 3, right) growing fairly rapidly reaching a diameter of 2.9 to 3.3 centimeters after 10 days at room temperature, predominantly submerged, spreading irregularly, loose-textured, thin, yellowish Red (7.5 R 8/4) to yellowish Red (7.5 R 6/8); surface growth consisting of tufts of loosely interwoven abnormally swollen closely-septate hyphal cells or a mixture of this type of cells and threadlike filaments; perithecia fairly abundant, many abortive.

IDENTITY

According to Clements and Shear(4) the distinctive characteristics of the fungus family Monascaceæ, a group of lower Ascomycetes, is the production of a typically well-developed, branched, septate, saprophytic mycelium forming conidia and sporangiumlike asci terminally on hyphal branches. This family comprises only one genus, the genus *Monascus* which has been described by the same authors to produce many-spored asci enclosed by interwoven hyphæ. This generic name according to Smith(12) was "bestowed at a time when the perithecium was thought to constitute a single, many-spored ascus. It is now known that normal asci are produced by this group of fungi as described by Barker;(1) but according to him these structures degenerate when the ascospores are ripe leaving the perithecium to appear like a cuticularized sporangiumlike body full of spores.

In a recent revision of the taxonomy of fungi Bessey(2) placed genus *Monascus* under family Aspergillaceæ and in his "Key to the Commoner Genera of the Family Aspergillaceæ" he described its distinctive characteristics as follows: "Perithecia small at maturity, with thin cortex, at first containing many eight-spored asci, but these and the surrounding tissues dissolve so that the spherical or ellipsoidal hyaline or red ascospores lie free," neckless, nonostiolate and without distinct hair coating or appendages, at least at maturity; "mycelium red or purple in mass; conidia single or in short chains."

By comparing the preceding description for genus *Monascus* with that discussed ahead for the red mold under study specifically with reference to sexual reproduction leading to perithecial and ascosporic development, the authors are convinced that the latter belongs to the *Monascus* group of Ascomycetes and appears to resemble either *M. purpureus* Went or *M. barkeri* Dangeard both of which were originally described from pigmented rice. Based on morphological characteristics the fungus in question conforms more closely to *M. purpureus* than to *M. barkeri* in conidial development, size and shape of ascorpores and pigmentation. This is substantiated by the close similarity of Went's original description and illustration(14) of the conidial and perithecial development of *M. purpureus* to those of the mold under consideration.

According to Young(15) "*M. purpureus* is characterized particularly by having ascospores which are usually spherical, being 5 microns in diameter or slightly ovoid, their size being 6 × 5 microns." Uyeda(13) describes similar structures to be generally ellipsoidal or oval, 5 to 6 microns long and 4 to 5 microns wide. The ascospores of the writers' red mold vary more widely in size than those of *M. purpureus* reported by the above authors but on the average they are slightly smaller.

The conidia of *M. purpureus* described by Uyeda(13) are generally ball-shaped, single or in chains and are very variable in size. The smaller forms which he called microconidia measure 6.5 to 8.5 microns in diameter. No measurements were given for the larger forms, the macroconidia. In the *Monascus* under present study these structures are formed in more or less the same fashion and are also as much diversified in size as Uyeda's *M. purpureus*.

According to Young(15) *M. barkeri* and *M. purpureus* are closely related. The one main difference between these two species is the non-production of pigment in solid cultures by the former and the formation of red coloration in solid substratum by the latter. The red mold in question behaves in a similar manner as *M. purpureus* when it is grown on solid agar or rice media.

The above discussion shows the closeness of features of the fungus under study to those of *M. purpureus* described by Went,(14) Uyeda,(13) Young,(15) and Olive(10) in pigmentation, conidial formation, and perithecial and ascosporic development. The similarity is so striking as to leave no doubt about their being identical. Henceforth, the red mold under investigation will be referred to as a strain of *Monascus purpureus* Went.

EXPERIMENTS ON RED-COLOR PRODUCTION ON RICE

PIGMENT PRODUCTION IN DIFFERENT COMMERCIAL RICE AND CORN VARIETIES

The following experiment was undertaken to determine on which of the commercial varieties of rice and corn the fungus (*M. purpureus*) would produce the dark-red color similar to that of the ang-kak sample described ahead. Ten different commercial varieties of rice and two of corn were obtained from a Manila market. For each variety, 3 jars each containing 50 grams of milled grains were used. Into each jar 30 cc of distilled water was added. Similar treatment was applied to the corn which was previously ground to smaller particles. All the jars were autoclaved at 15 pounds pressure for 30 minutes. After cooling down to room temperature each jar was inoculated with 5 cc of sterile-water suspension of ascospores obtained from a 25-day-old culture on Sabouraud's agar and then stirred to distribute the ascospores uniformly. The cultures were incubated at room temperature (29 to 32°C). After 3 days, when the rice was beginning to redden and when much heat was evolved, they were stirred and shaken to prevent profuse development of the mycelia and to aerate the growth. Henceforth, the cultures were stirred from time to time until the twentieth day. Then they were dried in the oven at 40°C.

Table 1 shows that *M. purpureus* is capable of growing well on all commercial nonglutinous varieties of rice and corn pro-

TABLE 1.—*Red color production on different Philippine commercial rice and corn varieties by M. purpureus.*

Variety	Ang-kak produced after 20 days incubation at room temperature (28 to 32° C)		
	Color	Extent of discoloration of the inner parts of the grains	Texture
Rice:			
Wagwag	purplish Red (2.5 R 4/8)	Complete	Soft, light, easily powdered between fingers.
Kinanda	purplish Red (2.5 R 5/6)	do	do
Elon-elon	purplish Red (2.5 R 4/8)	do	do
Consejala	purplish Red (2.5 R 4/10)	do	do
Macan	purplish Red (2.5 R 5/8)	do	do
Milagrosa	purplish Red (2.5 R 3/10)	do	do
Benser	purplish Red (2.5 R 5/6)	do	do
Apostol	purplish Red (2.5 R 5/8)	do	do
Raminad str. 3	purplish Red (2.5 R 5/8)	do	do
Malagkit Sungsung (glutinous)	Pigmentation not uniform		Gluey.
Corn (coarsely ground):			
Yellow flint	yellowish Red (7.5 R 2/6)	Complete	Hard.
White (nonglutinous)	purplish Red (2.5 R 2/6)	do	do

ducing on them the red color which in certain varieties appears to be similar to that of the ang-kak sample described ahead. On rice the coloring matter appears in different shades of purplish Red with Milagrosa variety as the darkest followed by Wagwag and Elon-elon, then by Consejala, then by Kinanda and Benser and then by Macan, Apostol, and Raminad Str. 3. The Chinese glutinous variety known as Malagkit Sungsung did not favor good growth of the red mold and production of red pigment because it was so gluey that the grains could hardly be separated from one another.

On white corn (nonglutinous strain) *M. purpureus* produced darker shade of purplish Red than either the Milagrosa rice or the ang-kak sample.

EFFECT OF COOKING RICE WITH VARYING AMOUNTS OF WATER ON THE QUALITY AND PIGMENTATION OF ANG-KAK PRODUCED BY M. PURPUREUS

Thirty-two 1-pint jars, each filled with 50 grams of Elon-elon rice and covered with Manila paper were divided into 8 batches, autoclaved with different amounts of tap water as shown in Table 2 and then inoculated with equal amounts of 25-day-old dried culture of *M. purpureus* in coarsely ground steamed rice. The cultures were incubated at room temperature (28 to 32°C).

As shown in Table 2, poor growth of *M. purpureus* was obtained in rice cooked with 10 and 15 cc water because the

TABLE 2.—*Red color production by M. purpureus on rice*[a] *autoclaved with varying amounts of water.*

Water used	Brief description of growth	Ang-kak produced after 20 days incubation at room temperature (28 to 32° C)	
		Color	Form and texture of the dried pigmented rice grains
cc			
10	Growth not easily obtained due to lack of moisture; restricted when present.		
15	Growth slow due to lack of moisture; reddening of the grains not uniform and not sufficiently intense to be appreciable.		
20	Growth fair; pigmentation of rice grains, uneven due to loss of much moisture as the culture ages.	purplish Red (2.5 R 5/8)	Plump, hard.
25	Growth good; pigmentation of rice grains, uniform and rapid.	do.	do.
30	do.	purplish Red (2.5 R 4/8).	Plump, easily powdered between fingers.
35	do.	purplish Red (2.5 R 3/8)	do.
40	do.	purplish Red (2.5 R 3/10)	Wrinkled, soft, light.
45	do.	do.	do.

[a] Original moisture content of rice, 11 per cent.

cultures were not sufficiently moist to allow normal development of this mold. At an incubation temperature of 28 to 32°C, the moisture in all cultures evaporated rather fast and in the 10- and 15-cc batches, it was reduced to a point so critically low as to cause slackening or inhibition of the growth of the organism. In 20- and 25-cc batches the growth of the red mold was fair and good, respectively, but the ang-kak produced, although plump, was hard and could not be powdered between fingers. The best of the ang-kak produced was in 30- and 35-cc batches. The grains were plump, dark purplish red and could easily be reduced to powder by rubbing between fingers. The objectionable feature of the ang-kak produced at 40- and 45-cc batches was that it was spongy, too soft and very light.

RELATION OF TEMPERATURE TO THE RED-COLOR PRODUCTION ON RICE BY M. PURPUREUS

To determine the temperature favorable for the production of intense red color on rice by *M. purpureus* the following experiment was conducted:

Sixteen jars each containing 50 grams of Elon-elon rice and 30 cc of water were autoclaved at 15 pounds pressure for 30 minutes. After cooling down to room temperature they were inoculated each with 5 cc of the ascospore suspension of *M. purpureus* in sterile water. They were divided into batches of 4 jars each and then incubated at 20°, 27°, (28 to 32°C) room temperature and 37°C. After 15 days the cultures were dried in the oven at 40°C.

Table 3 shows that *M. purpureus* is capable of growing at a wide range of temperature conditions. There is an indication that it can grow at a temperature lower than 20°C and at a level higher than 37°C but although the red color is produced on rice in all batches its optimum intensity occurs in the batch placed at 27°C followed closely by the one placed at room temperature (28 to 32°C). At 20°C the growth of the ang-kak mold is slow as a result of which reddening of the grains becomes uneven. At 37°C the ang-kak mold shows a strong tendency to produce a profuse growth of white or grayish mycelium on the surface of the substratum.

PIGMENTATION OF PRESOAKED RICE BY M. PURPUREUS

Eight hundred grams of clean Elon-elon rice were washed with three changes of tap water. In a pan, the rice was immersed in water and left for 24 hours, changing the latter

TABLE 3.—*Effect of different incubation temperatures on growth of the red mold and red-pigment production on steamed Elon-elon rice.*

Temperature of incubation	Observation on growth	Color of ang-kak produced after 20 days of incubation
°C		
20	Delayed growth; early signs of growth shown after fourth day; reddening of grains began on the fifth day.	Red (5.0 R 5/10), unevenly distributed on rice grains.
27	Growth fast; reddening of grains began on second day.	purplish Red (2.5 R 3/10), evenly distributed on grains.
28 to 32 (Room temperature)	do	do
37	Growth fast with tendency to produce thick white mycelial mat on surface, reddening began after seventh day.	purplish Red (2.5 R4/10); pigmentation uneven; grains have hardened due to rapid evaporation of water.

two times in order to prevent active growth of microbial contaminants that might have been present in the mixture. The water was drained until no more of it dripped. After ascertaining the amount of water that it had absorbed, the rice was distributed in equal amounts into 16 jars. The jars were divided into four batches and then water was added into each as shown in Table 4 (fourth column). All of them were

TABLE 4.—*Red-color production by M. purpureus on rice*[b] *presoaked for 24 hours in water, cooked by autoclaving with different amounts of water and kept moist by adding sterile water to the culture at predetermined time.*

Batch	Equivalent weight of rice in each jar in dry form	Water used in each jar					Ang-kak produced after 20 days incubation at 27° C		
		Amount imbibed by the rice during soaking	Amount added to presoaked rice before autoclaving	Sterile water used for suspending the inoculant	Sterile water added from time to time to maintain moistness of culture	Total	Color	Grains showing complete discoloration of inner tissues (based on 100 grains)	Texture of dried pigmented rice grains
Number	*gms*	*cc*	*cc*	*cc*	*cc*	*cc*			
1	50	15.0	0.0	5.0	15.0	35.0	purplish Red (2.5 R 3/6)	95	Brittle, easily powdered between fingers.
2	50	15.0	5.0	5.0	10.0	35.0	do	96	do
3	50	15.0	10.0	5.0	5.0	35.0	do	95	do
4	50	15.0	15.0	5.0	0.0	35.0	purplish Red (2.5 R 2/6)	98	Soft, light, easily powdered between fingers.

[b] Original moisture content of rice, as in footnote a on page 11.

covered with thick Manila paper and then autoclaved for 30 minutes at 15 pounds pressure. After cooling them down to room temperature, they were each inoculated with 5 cc sterile-water suspension of ascospores of *M. purpureus*, stirred to distribute uniformly the inoculant and then incubated at 27°C. Sterile water was added at predetermined time to the cultures to keep them always moist. After 20 days the ang-kak was harvested and dried.

All batches showed profuse growth of *M. purpureus* on rice accompanied by the production of red color which gradually increased in intensity until after a lapse of two weeks the color indicated in Table 4 was attained. There was hardly any difference at all between any of the batches in the color of ang-kak produced. The ang-kak harvest from batch No. 4 had slightly deeper pigmentation, nevertheless, it was considered to be inferior to the other batches because the grains in it were soft, light and less plump. On splitting lengthwise 100 unbroken grains from each batch it was observed that nearly all of them were completely impregnated with the red color. The best harvest of ang-kak was obtained from batch No. 1 because the grains from it were brittle, plump and crushable to powder between fingers. Except for the fact that the grains from them showed slight distortion of shape, the ang-kak produced from batches No. 2 and No. 3 could be ranked with that from No. 1. Henceforth, the method followed by the writers in subsequent studies on ang-kak production were as described for batch No. 1.

RED-COLOR PRODUCTION BY M. PURPUREUS ON RICE COOKED AND MOISTENED WITH WATER OF VARIED pH

Stocks of distilled water of pH 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, and 7.5 were prepared and then checked for correctness of adjustment.

Thirty weighed wide-mouthed 1-pint glass jars each containing 50 grams of Elon-elon rice were subdivided into ten batches of 3 jars each. The rice in different batches was flooded with water (60 cc per jar) of different pH mentioned ahead. After 24 hours the unabsorbed water in each jar was poured out and then the rice was washed with two changes of the same water in which it was previously soaked. Covering the mouth of the jars with clean coarse cheesecloth, the water was drained out until no more of it dripped. After determining the amount of water absorbed all of the jars were covered with thick Manila paper and then autoclaved for 30 minutes at 15 pounds pressure. As soon as they cooled down to room temperature, they were each inoculated with the ascospores of the red mold in suspension in sterile water of similar pH as that used for soaking the rice. Water of the same pH was also used in maintaining the moistness of the cultures in order to keep the mold actively growing for a longer period. After 20 days the ang-kak produced was dried and pertinent observation about it recorded.

TABLE 5.—*Relation of pH* [c] *to red-color production on rice by M. purpureus.*

pH of water	Ang-kak produced after 20 days' incubation at 27 to 28° C		
	Color	Grains showing complete discoloration of inner tissues (based on 100 unbroken grains)	Texture
		Per cent	
3.0	purplish Red (2.5 R 4/6)	98	Brittle, easily powdered.
3.5	purplish Red (2.5 R 3/10)	95	do
4.0	purplish Red (2.5 R 3/8)	97	Soft, easily powdered.
4.5	purplish Red (2.5 R 3/6)	98	do
5.0	purplish Red (2.5 R 3/8)	96	do
5.5	do	97	do
6.0	do	97	do
6.5	do	96	do
7.0	do	97	do
7.5	do	99	do

[c] Amount of water of each of the above pH used per jar:

Absorbed by the rice during soaking, about	16.0 to 17.0 cc.
Utilized for suspending ascospore inoculant	5.0 cc.
Used for maintaining moistness of cultures	9.0 cc.
Total	30.0 to 31.0 cc.

Vigorous growth of the red mold was obtained in all batches treated with water of different pH. There was no sign of any inhibitory action of any given pH on growth of the mold under study. From pH 3 to pH 7.5 the initial reddening of the rice substratum was observed on the same day. During the first two weeks of incubation no visible difference between any of the batches with respect to coloration of the rice was observed. At the close of the experiment the difference in the intensity of pigmentation that was observed between any of the treatments was so minor that it could not be taken as sufficient evidence that it was influenced at all by any given hydrogen-ion concentration. From the results shown in Table 5 it appears that the red mold under study can thrive under a wide range of initial pH and wherever the growth is vigorous red coloration is intense.

RED-COLOR PRODUCTION BY M. PURPUREUS ON RICE ACIDIFIED WITH LACTIC ACID OF VARIOUS CONCENTRATIONS

In his studies of the physiological characteristics of genus *Monascus* Young(15) observed a pronounced tolerance of Strain E of *Monascus ruber* Van Tieghem to lactic acid and that while there is no accompanying red coloration in high dilutions of the acid, it appears and increases in intensity at higher concentrations (0.5 to 2.5 or more per cent). If *M. purpureus,* a member of the same group of molds to which *M. ruber* belongs, can be induced to produce ang-kak consisting of plump, bright red grains by lactic acid treatment such product, being very attractive, would command a good price in the market. An experiment aiming at this possibility was conducted, as shown in Table 6, not to determine the limits of toleration of *M. purpureus* in lactic acid but rather to find which concentration of this acid would induce the mold to produce rich red pigment on rice.

TABLE 6.—*Effect of lactic acid solution*[a] *on red color production by M. purpureus on rice.*

Lactic acid solution used					Ang-kak produced after 20 days incubation at 27 to 28° C		
Concentration	Amount absorbed by the rice during soaking	Volume used for suspending the ascospore inoculant	Volume used for maintaining moistness of the culture	Total	Color	Grains showing complete discoloration of inner tissues (based on 100 grains)	Texture
Per cent	*cc*	*cc*	*cc*	*cc*		*Per cent*	
0.00	15.8	5	10	30.8	purplish Red (2.5 R 2/4)	99	Soft, easily powdered
0.05	15.1	5	10	30.1	----------do----------	98	----do----
0.10	15.1	5	10	30.1	purplish Red (2.5 R 3/4)	99	----do----
0.50	15.0	5	10	30.0	purplish Red (2.5 R 4/8)	96	----do----
1.00	15.6	5	10	30.6	purplish Red (2.5 R 5/6)	98	----do----
1.50	16.5	5	10	31.5	----------do----------	91	----do----
2.00	16.8	5	10	31.8	----------do----------	92	----do----
2.50	16.8	5	10	31.8	----------do----------	95	Brittle, easily powdered.
3.00	16.5	5	10	31.5	purplish Red (2.5 R 5/4)	96	----do----

[a] Three 1-pint jars, each containing 50 grams Elon-elon rice, were used for each concentration of lactic acid solution. The rice in each jar was soaked in 60 cc of lactic acid solution except for 0.00 per cent in which only distilled water was used. After 24 hours it was washed with the same solution, drained and then weighed to determine how much solution had been absorbed. The rice was autoclaved for 30 minutes at 15 pounds pressure, cooled and then inoculated with ascospore suspension of *M. purpureus.* The culture was kept moist by adding at predetermined time, lactic acid solution of the same concentration.

Early noticeable growth of *M. purpureus* as shown by the reddening of inoculated rice was first observed two days after inoculation in a batch containing no lactic acid. It was shown after 3 days at 0.05 and 0.1 per cent concentrations and after 6 days at the remaining other concentrations. The delay in the appearance of growth at higher concentrations can be attributed to the inhibitory effect of lactic acid.

The results shown in Table 6 reveal that the presence of lactic acid in the rice substratum did not induce the red mold to produce ang-kak with deeper red color as the batches that showed the deepest red pigment were the ones containing no lactic acid and the one with the least amount of it. The ang-kak produced in each batch consisted of grains which were plump, uniform in color and could readily be powdered by rubbing between fingers.

THE B-VITAMINS OF ANG-KAK

The vitamins of the B group (thiamin, riboflavin and niacin) are present in ang-kak in varying amounts, depending largely on the technique of its preparation, intensity and thoroughness of impregnation of the red color into the rice grain. As shown in Table 7 *M. purpureus* is perhaps incapable of synthe sizing thiamin and as, shown by Ang-kak 2 and Ang-kak 3, there is a sign that it uses up this vitamin in the process of growth. There appears to be an appreciable increase in the amount of riboflavin showing that the red mold is capable of synthesizing this vitamin. In the case of niacin, there are indications that under certain conditions shown by Ang-kak 1, this vitamin is synthesized in substantial quantity by the mold and at certain other unknown conditions it is abstracted from the rice substratum as shown by Ang-kak 2.

TABLE 7.—*Amount of thiamin, riboflavin and niacin in elon-elon rice and in the ang-kuk produced from it per 100 grams of dry sample.*

Sample	Color	Thiamin	Riboflavin	Niacin
		Milligrams	*Milligrams*	*Milligrams*
Elon-elon rice	White	0.120	0.040	2.40
Ang-kak 1	purplish Red (2.5 R 3/4)	0.126	0.940	6.60
Ang-kak 2	purplish Red (2.5 R 4/10)	0.025	0.725	0.63
Ang-kak 3	purplish Red (2.5 R 3/8)	0.056	0.665	0.40

SUMMARY

1. The present research on ang-kak had been stimulated by an insufficient supply of this product in the Philippines for use in coloring and flavoring fish and other food products. From an ang-kak sample obtained from a Manila market, the red mold used in the experiments on the manufacture of the product herein reported was successfully isolated.

2. Studies on the morphological features of the ang-kak organisms showed that it belongs to the *Monascus* group of Ascomycetes. One very striking characteristic of this mold, on which no report is shown in the available literature, is the extrusion through the tips of many of its hyphæ of their granular contents which gradually become reddish and which are largely responsible for imparting red color to the culture. By comparing, however, its conidial and perithecial development, size and shape of conidia and ascospores and its cultural characteristics with other recognized species of *Monascus* cited in literature, the red mold under study is found to be closely related to *Monascus purpureus* Went and is here considered to be a strain of this species.

3. The strain of red mold under study can tolerate a wide range of pH and seems to grow equally well at different pH from 3.5 to 7.5. Optimum temperature for red-color production on rice by this mold is about 27°C.

4. Except the glutinous species known locally as Malagkit Sungsung, all of the other commercial varieties of rice; namely, Wagwag, Kinanda, Elon-elon, Consejala, Macan, Milagrosa, Benser, Apostol and Raminad Str. 3, were found suitable for use in ang-kak manufacture. The choice of the variety should be made on the basis of its greater availability and lower cost.

5. Of the several methods tried for the production of ang-kak, the one that gave the best result was by growing the mold on autoclaved rice previously soaked in water for 24 hours and adding sterile water to the culture at predetermined time to maintain its moistness and keep the organism in it in a vigorous state of growth.

ACKNOWLEDGMENT

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REFERENCES

1. BARKER, B. T. P. The morphology and development of the ascocarp in Monascus. Ann. Bot. 17 (1903) 167–236, pls. 12–13. Cited in Olive, Edgar W. The morphology of Monascus purpureus. Bot. Gaz. 39 (1905) 56–60.
2. BESSEY, E. A. Morphology and Taxonomy of Fungi. Philadelphia: The Blackiston Co. (1952) xiii + 791 pp., 210 figs.
3. CHURCH, MARGARET B. Laboratory experiments on the manufacture of Chinese ang-khak in the Unitel States. Jour. Ind. Eng. Chem. 12 (1920) 45–46.
4. CLEMENTS, FREDERIC E., and CORNELIUS L. SHEAR. The Genera of Fungi. New York: The H. W. Wilson Co. (1931) iv + 496 pp., pls. 1–58.
5. GIBBS, H. D., and F. AGCAOILI. Some Filipino foods. Philip. Jour. Sci. 7 (1912) 383–401, Pls. 1–6.
6. GWYNNE-VAUGHAN, H. C. I., and B. BARNES. The Structure and Development of the Fungi. London: Cambridge University Press (1958) xvi + 449 pp.
7. HISIEH, CHIU TAOH. Hung-chü I. Enzymic activities of Hung-chü. Jour. Orient. Med. 31: 741-749. Cited in the Chem. Abst. 34 (1940) 1696.
8. IKENO, S. Ueber die Sporenbildung und systematische stellung von Monascus purpureus Went. Ber Deutsch. Bot. Gesell. 21 (1903) 259–269, pls. 1–13. Cited in Olive, Edgar W. The morphology of Monascus purpureus. Bot. Gaz. 39 (1905) 56–60.
9. NISHIKAWA, HIDEJIRO. Biochemistry of filamentous fungi. I. Coloring matters of Monascus purpureus Went. Jour. Agr. Chem. Soc., Japan 8 (1932) 1007–10015. Cited in Chem. Abst. 27 (1933) 1629.
10. OLIVE, EDGAR W. The morphology of Monascus purpureus. Bot. Gaz. 39 (1905) 56–60.
11. SCHICKORRA, W. Uber die Entwicklungsgeschichte von Monascus. Zeit. Bot. 1 (1909) 379–410, Pl. 2, figs. 1–3. Cited in Bessey, E. A. Morphology and Taxonomy of Fungi. Philadelphia: The Blackiston Co., (1952) xiii + 791 pp., 210 figs.
12. SMITH, GEORGE. An Introduction to Industrial Mycology. 3d. ed. London: Edward Arnold and Co. (1946) xiv + 271 pp.
13. UYEDA, Y. Ueber den "Benikoji" pilz aus Formosa. Bot. Mag. Tokyo 15 (1901) 100–103, Pls. 1–2.
14. WENT, F. A. F. C. Monascus purpureus le champignon de l' Ang-Quac une nouvelle Thelebolee. Ann. Sci. Nat. Bot. Ser. 8 (1895): 1: 18, Pls. 1–2.
15. YOUNG, ELAINE M. Physiological studies in relation to the taxonomy of Monascus spp. Trans. Wis. Acad. Sci. Arts and Lett. 25 (1930) 227–244, Pls. 3–4.
16. YOUNG, ELAINE M. The morphology and cytology of Monascus ruber Amer. Jour. Bot. 18 (1931) 499–517, Pls. 391–41.

ILLUSTRATIONS

[Photomicrographs by Clodualdo S. Angbengco.]

PLATE 1

FIG. 1. Section of a 4-day-old colony of the ang-kak mold in a plate of Sabouraud's agar profusely dotted with red-colored extrudes from the mold's hyphæ; approximately, × 127.

2. Two advancing hyphæ from a colony of a two-day-old micro slide culture of the ang-kak mold on Sabouraud's agar one of which is seen extruding the granular contents through its tip; approximately, × 538.

PLATE 2

FIG. 1. Globular masses of granular material freshly extruded from hyphæ of a 60-hour-old micro slide culture of ang-kak mold on Sabouraud's agar; approximately, × 528. The extrudes appear as guttatelike granular fluid resting on tips of hyphæ.

2. Dispersion of the extruded granular particles about the tips of the hyphæ of a 3-day-old micro slide culture of ang-kak mold on Sabouraud's agar; approximately, × 528.

PLATE 3

FIG. 1. An instance in which the granular particles were extruded with some force from hyphal tips of a 4-day-old micro slide culture of ang-kak mold on Sabouraud's agar which spread them over wider area; approximately, × 486.

2. Conidiophores and chains of conidia of the ang-kak mold from a 3-day-old micro slide culture on Sabouraud's agar; approximately, × 486.

PLATE 4

FIG. 1. Cases of vivipary of conidia of the ang-kak mold; approximately, × 547.

2. Section of a colony of a 10-day-old plate culture of ang-kak mold on Sabouraud's agar showing the development and distribution of perithecia; approximately, × 124.

PLATE 5

FIG. 1. A perithecium showing a casement of interlaced hyphæ and a development of numerous ascospores within; approximately, × 1295.

2. A perithecium encased by cuticularized wall of interlaced hyphæ within which are shown numerous mature ascospores; approximately, × 1295.

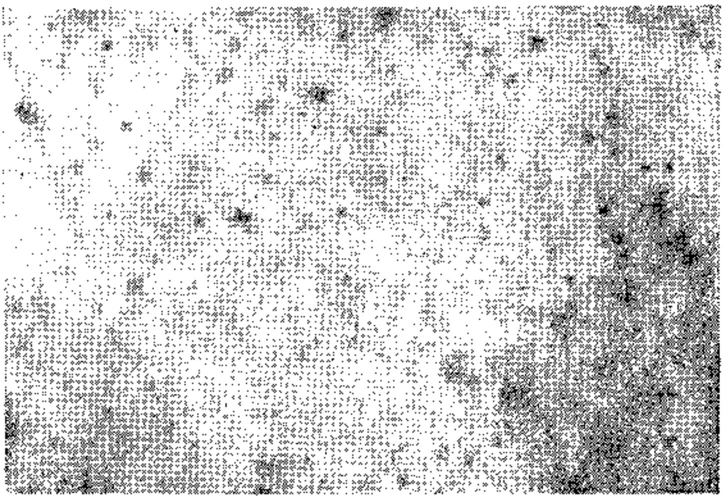
PLATE 6

[Ten-day-old plate cultures of ang-kak mold.]

FIG. 1. On Sabouranud's agar.
2. On potato-dextrose agar.
Left, on Czapek's solution agar (3 per cent dextrose); right on Czapek's solution agar (3 per cent sucrose).

TEXT FIGURES

FIG. 1. Camera lucida drawing of the different parts of the ang-kak mold in micro slide culture on Sabouraud's agar; approximately, × 204; *a*, extrusion of granular fluid from germ tubes of a viviparous conidium; *b*, profuse formation of chains of conidia. Note a viviparous conidium with germ tube extruding granular fluid which later turned red; *c*. germinating conidia; *d*, perithecium-initials. Note the development of antheridium and ascogonium at the extremities of hyphæ which were to become stalks of the perithecia and the fusion between the tip portion of the ascogonial branch and the basal or middle part of the antheridial branch; *e*, early stages of perithecium development showing the "invagination" of the swollen central ascogonial cell by "somebody" which entered near the side on which the stalk is seen; *f-g*, young perithecia as they appeared before the formation of asci and ascospores; *h*, germination ascospores.



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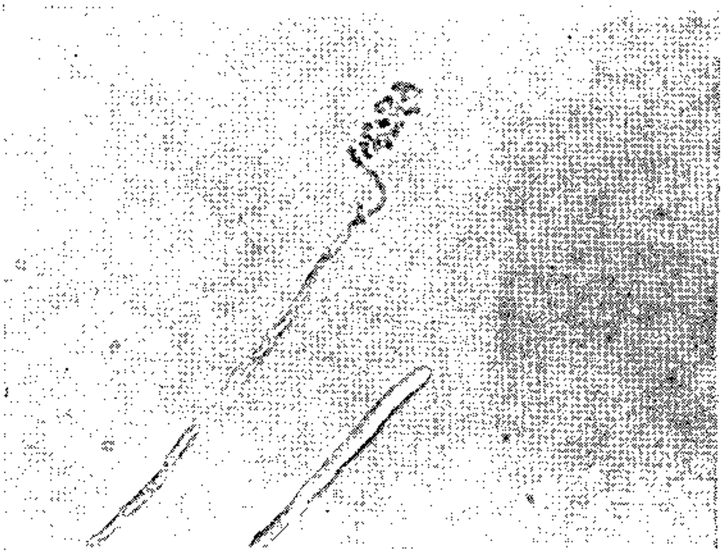

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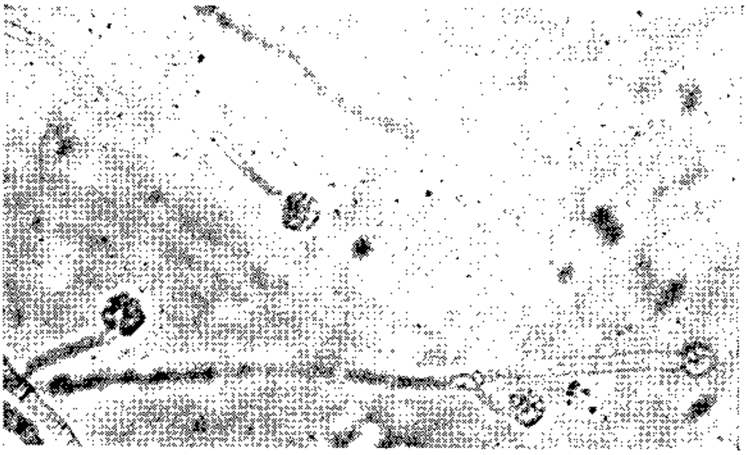

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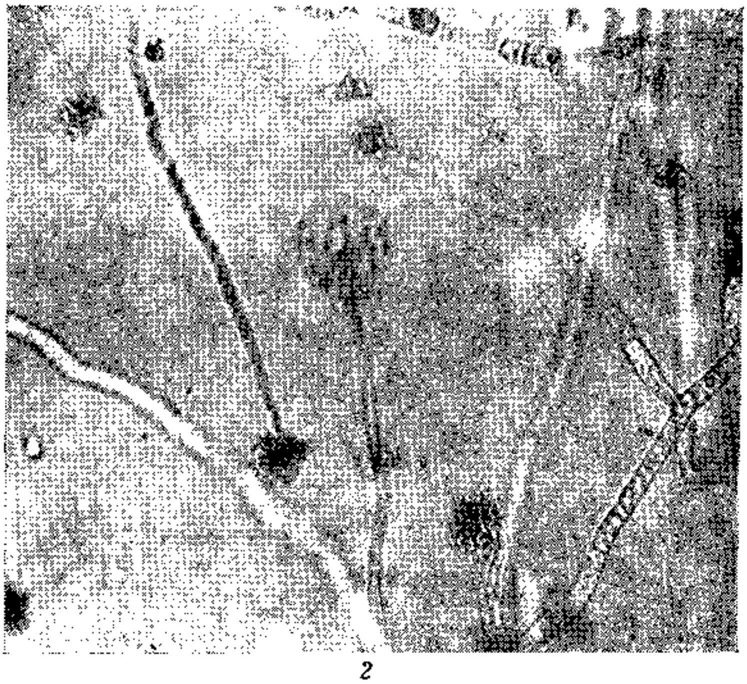

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PLATE 2.

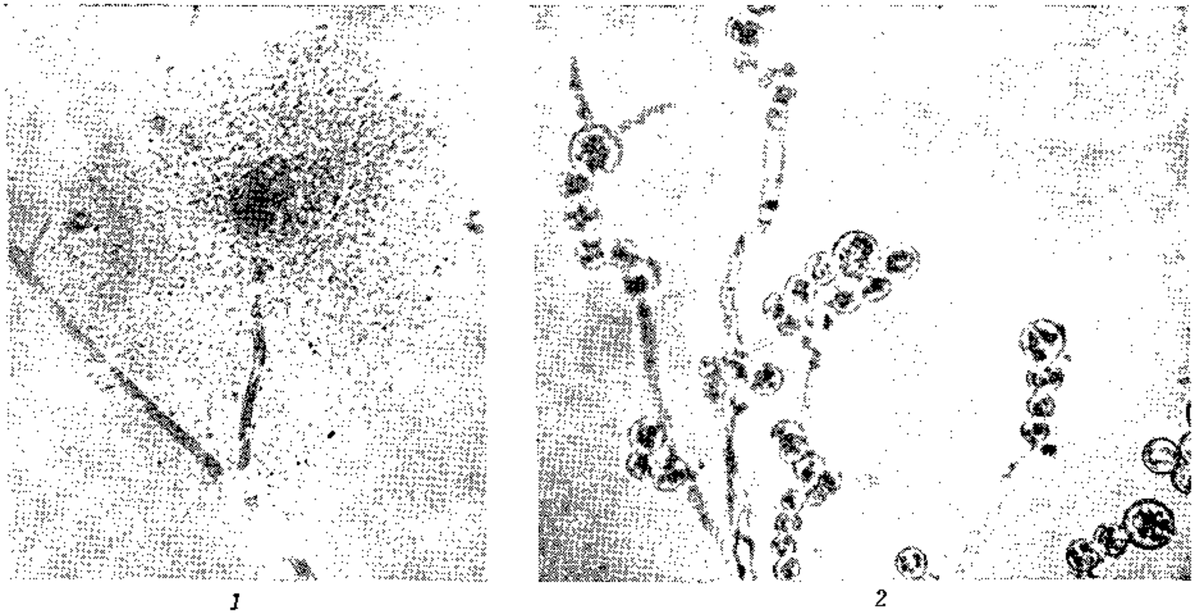

PLATE 3.

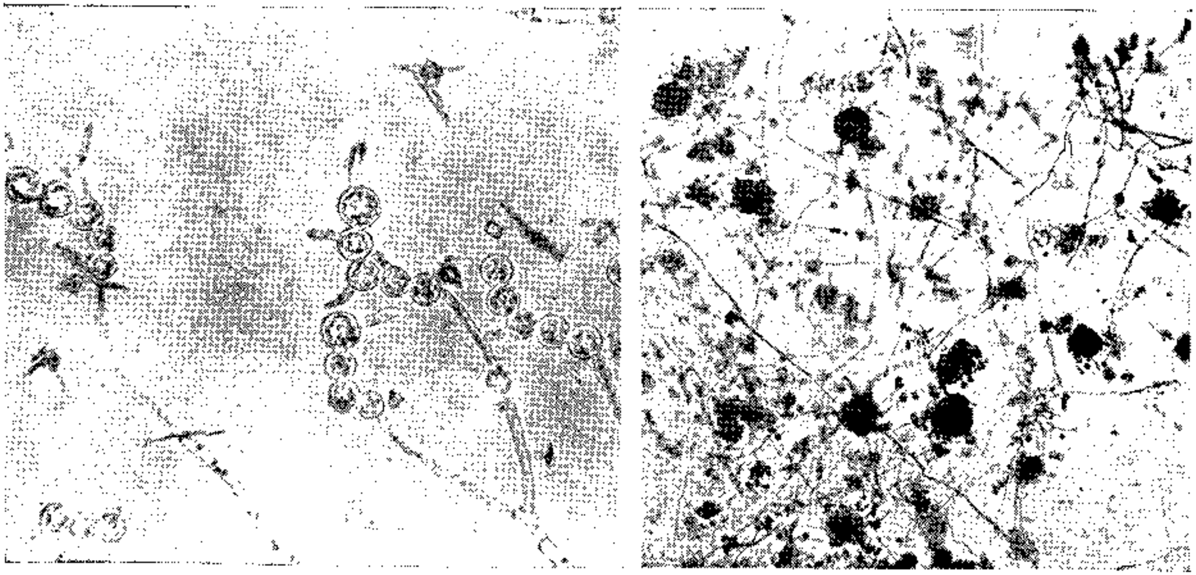

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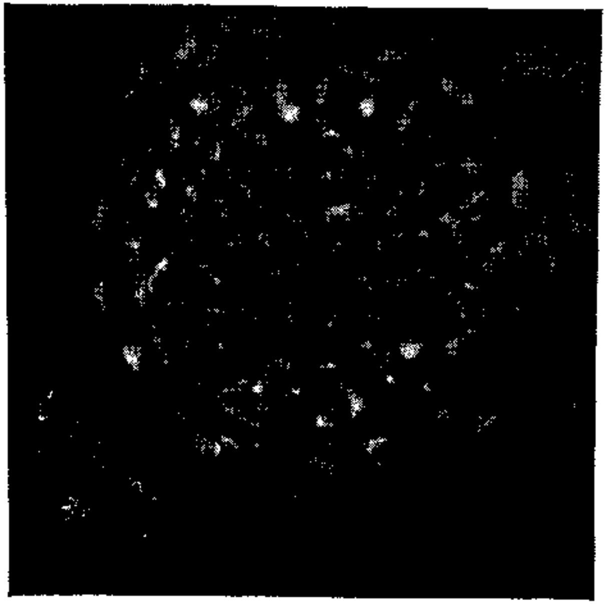
PLATE 4.



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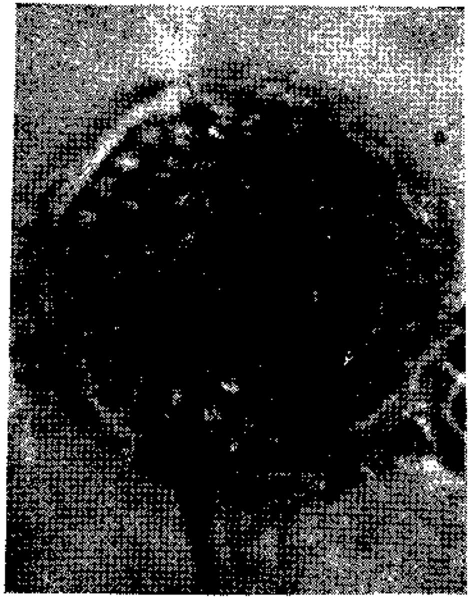

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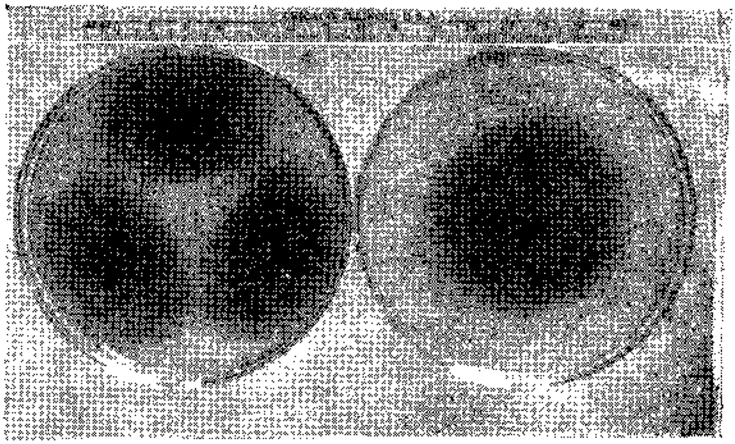
PLATE 5.



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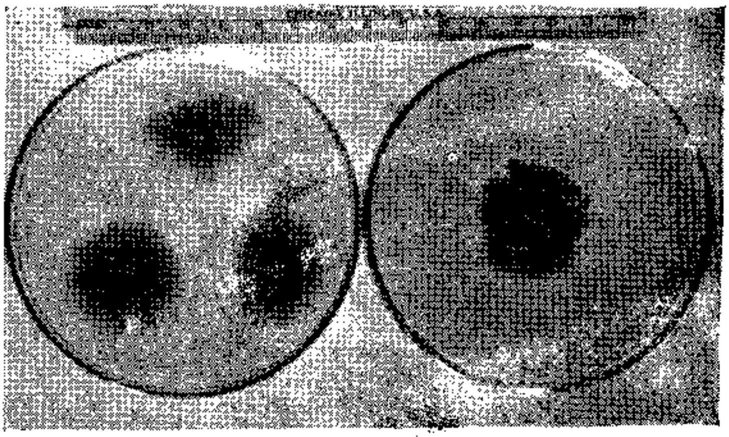

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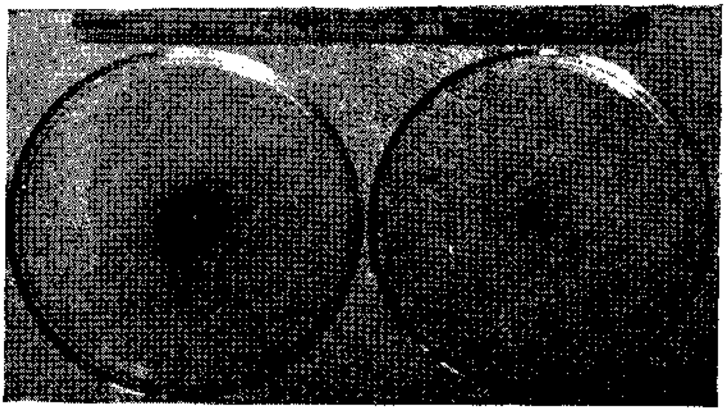

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PLATE 6.

THE DEXTRAN-LEUCONOSTOC FROM PHILIPPINE CABBAGE: SOME FACTORS INFLUENCING DEXTRAN FORMATION AND SPECIFIC IDENTITY OF THE ORGANISM

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TWO PLATES

Dextran, dextrose hydrate, according to Arrhenius,(4) was first noticed in 1869 by Scheibler who examined lumps of mucus formed in sugar solutions and thought it to be plasma of beet cells, but it was Jubert in 1874 who proved that it was not developed in sugar solution which was previously heated to 90°C for half an hour. The same author also cited that in 1878 Van Tieghem gave the generic name *Leuconostoc* to the chain-forming coccus producing dextran.

Gum dextran is also produced by culturing *Leuconostoc* in artificial medium containing, essentially, 10 per cent sucrose, sufficient quantity of peptone, nutrient salts and some accessory stimulatory factors supplied by molasses, yeast extract, or vitamins.

Early investigations on the formation of dextran were very limited due perhaps to its seeming insignificant economic importance, the nuisance it causes in sugar factories. The outbreak of the Second World War, however, stimulated great interest in the production of dextran which, if partially hydrolyzed and fractionated, has since been successfully used as a blood volume expander.(1–3, 6, 8, 9, 11–17, 20, 21, 23, 26) Dextran is also reported as a good stabilizer for sugar sirups,(18, 25) ice cream and other confections, and is, according to Underkofler(24) the basis for operation of a company in the United States. The same author cites the suitability of some ethers, esters and mixed ether-esters of dextran in the preparation of lacquers as covered by 18 patents in the names of Stahly and Carlson. Russell,(22) in his patent, claims that 0.1 to 3 per cent raw or native dextran added to dental cream or dentrifices increases the cleansing power of these preparations.

In view of the great industrial possibilities cited for dextran, this study was undertaken. The investigation was limited to the search, from Philippine microflora, for an efficient dextran-forming *Leuconostoc*, determination of optimal conditions for gum formation by the selected strain, and determination of its specific identity.

EXPERIMENTAL PROCEDURE

Isolation of dextran-forming Leuconostocs.—The microorganisms were isolated by pour plate dilution from infusions of fermenting fruits, vegetables, and other plant parts. A solid medium prepared by adding agar to the Leuconostoc basal medium, developed by Baens-Arcega and Yenko(5) in their study of *Leuconostoc dextranicum*, was used. The plate cultures were incubated at room temperature (28° to 30°C) for 2 days. Isolated single colonies, which were convex, transparent, mucoid and smooth-edged, distinct cultural characteristics of dextran-formers belonging to the genus *Leuconostoc*, were fished out and streaked on agar slants consisting of the medium mentioned above.

Selection of most efficient dextran-forming species of Leuconostoc.—The 2-day-old pure cultures of the different isolates on agar slants, were tested for dextran-forming efficiency by inoculating them separately into test tubes, each containing 10 cc of the Leuconostoc medium (pH 7.2) of Baens-Arcega and Yenko.(5) After 2 days of incubation at room temperature the different test tube cultures were examined for growth and dextran formation. The appearance of the liquid cultures varied from thin and cloudy to viscous and opaque. Cultures that were very viscous gave high yields of gum, which were determined quantitatively by precipitating with alcohol and weighing the dried product. The dextran yield was computed on the basis of the sucrose content of the medium.

Among 32 gum-forming isolates from different sources, that from cabbage (*Brassica oleracea* Linn. var. *capitata* Linn.) produced the highest yield of a water-soluble dextran, which, upon hydrolysis with dilute hydrochloric acid, produced a dextrorotatory substance that reduced Fehling's solution indicating the presence of dextrose. The cabbage isolate was therefore selected for this study.

Test for suitability of Baens-Arcega and Yenko Leuconostoc liquid medium for gum formation by the cabbage isolate.—The theoretical yield of dextran (47.37 per cent on the sucrose used) was produced in the Leuconostoc medium by *L. dextranicum* as reported by Baens-Arcega and Yenko.(5) Similar experiments performed by the above authors for *L. dextranicum* were carried out for the cabbage isolate in the same medium. Results of separate tests on the effect of pH or temperature of incubation on dextran formation by the organism under study were irregular. Slightly better yields, however, were obtained from cultures incubated at 20°C. It was held probable that an accessory stimulatory factor for the synthesis of dextran by the cabbage organism was not supplied by the molasses in the Leuconostoc medium. On the other hand molasses offered the drawback of imparting a brown color to the precipitated dextran.

Development of a new basal medium and search for other sources of accessory stimulatory factors.—Hucker and Pederson(7) state that growth of *Leuconostoc* is enhanced by yeast, tomato or other vegetable extracts. It is possible that the extracts mentioned contain not only factors for growth but also accessory stimulatory factors for dextran synthesis. A new modified Leuconostoc medium containing yeast extract was therefore prepared. Its composition is as follows:

	Grams
KCl	1.00
NaH_2PO_4	1.00
$M_gSO_4.7H_2O$	0.10
$NaHCO_3$	0.25
Peptone	1.00
Yeast extract	2.00
$CaCl_2$ (2 per cent solution)	2.50 cc
Sucrose (refined)	100.00
Water q. s.	1000.00 cc

When the cabbage organism was cultured in the above medium, yields were also very irregular, showing that the stimulatory factor for dextran formation had not also been supplied by the yeast extract.

Whiteside-Carlson and Carlson(27) in their experiments demonstrated that thiamine, nicotinic acid and pantothenic acid in amounts of 0.01, 0.1 and 0.1 μg./ml., respectively, were essential vitamins in the synthesis of dextran by *L. mesenteroides* and *L. dextranicum.* Incorporation of thiamine and nicotinic acid, in the same concentrations used by these investigators, to the modified Leuconostoc medium did not materially affect dextran yields by the cabbage organism.

Since the organism under study was isolated from cabbage it is possible that the missing stimulatory factor for dextran synthesis may be supplied by this vegetable. A decoction of cabbage was therefore used instead of water as solvent for the peptone, yeast extract, salts, and sucrose of the modified Leuconostoc medium. In this medium, dextran was regularly produced in large amounts indicating that the accessory stimulatory factor had been supplied by the cabbage extract.

Concentration of cabbage extract sufficient to supply necessary stimulatory factor for dextran formation.—The minimal concentration of cabbage extract which could supply the necessary stimulatory factor for maximum dextran formation by the organism was determined in the following manner: Cabbage leaves were washed with water and then shredded. Four hundred grams of the finely cut leaves was placed in 2 liters of boiling water contained in a covered casserole and the same was boiled for 15 minutes. The hot extract was first strained through muslin, then through filter paper. For convenience, one liter of the clear filtrate was assumed to contain the extractives from 200 grams of cabbage. This decoction served as the 20 per cent stock cabbage extract. Six batches of modified Leuconostoc medium were separately enriched with varied amounts of cabbage decoction. The media thus prepared contained different concentrations of cabbage extract: 5, 10, 15, and 20 per cent. Each medium was distributed in 10 cc portions into test tubes which were plugged with cotton and sterilized at 15 lbs steam pressure for 30 minutes. The media were allowed to cool.

From each concentration, one tube was taken for pH determination and 6 test tubes were inoculated with a 2-day-old culture of cabbage organism and then incubated at 20°C. It was mentioned in the first part of this paper that better yields of dextran were obtained when the organism was incubated at this temperature. As checks, 6 tubes containing modified Leuconostoc medium (without cabbage extract) were also inoculated with the organism from the same culture and incubated at the same temperature. At the end of 2 days, the different cultures were observed and determinations for yields of dextran and pH were made. Table 1 and succeeding tables show the average yields of dextran from repeated tests.

Dextran formation was observed in all of the 2-day-old tube cultures. Cultures in media containing 20 and 0 per cent cabbage extract were viscous but easy to pour and the yields of dextran were 39.08 and 33.4 per cent, respectively.

TABLE 1.—*Effect of the addition of cabbage extract to the medium on dextran yields.*

Concentration of cabbage extract in medium	pH of medium after sterilization	Results of 2 days fermentation	
		pH	Dextran formed
Per cent			*Per cent*
0.0	6.6	4.0	33.40
5.0	6.4	3.9	40.27
10.0	6.4	4.0	46.06
15.0	6.8	4.1	40.11
20.0	6.8	4.0	39.08

NOTE: Media with different concentrations of cabbage extract were prepared by adding computed amounts of stock cabbage extract to modified Leuconostoc medium.

Those in media containing 5 and 15 per cent cabbage extract, which appeared more viscous and could hardly be poured, yielded more dextran, about 40 per cent in both cases. The cultures in 10 per cent cabbage extract were the thickest, such that the culture tubes could be inverted without any outflow of the cultures. They were found to contain an average of 46.06 per cent dextran, the highest yield obtained in this experiment. The discrepancy in the amounts of dextran formed by the organism in the different media could not have been due to the difference in the pH since the media containing 5 and 10 per cent of cabbage extract have the same initial pH of 6.4. The dextran formed in these two concentrations were 40.27 and 46.06 per cent, respectively. Neither could it possibly be due to the acid formed by the organism because the 10 per cent yielded 46.06 per cent dextran while the 0 per cent gave only 33.4 per cent although both cultures had the same pH of 4 after two days' fermentation. It is apparent that 10 per cent cabbage extract added to the modified Leuconostoc medium supplied the necessary stimulatory factor for the organism to produce dextran.

Relation of pH to dextran formation.—To determine the relation of pH to dextran formation, 1 liter of cabbage-enriched Leuconostoc medium was prepared and divided into 100 cc portions, in 250 cc beakers. The portions were adjusted separately to pH: 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, and 9.0 and then distributed in 10 cc portions into 25 cc test tubes which were plugged with cotton and sterilized at 15 lbs for 30 minutes. After cooling the sterilized media, their pH was again determined and was found to have changed. From each medium of different pH levels, three tubes were inoculated with 2-day-old cabbage organism and incubated at 20°C. After 2 days of fermentation, the dextran formed in the tube cultures was determined.

Table 2 shows that the cabbage organism produced dextran in a wide range of pH from 4.6 to 7.55. As the reaction of the medium approached neutrality, the yield of 10.08 per cent gum at pH 4.6 was gradually increased, reaching a maximum of 46.43 per cent at pH 6.7 which is apparently the optimum for dextran formation. This is substantiated by reduced yield as the reaction of the medium became alkaline, being 42.12 per cent at pH 7.55.

TABLE 2.—*Relation of pH to dextran formation.*

pH of medium *		Dextran formed after 2 days' fermentation
Before sterilization	After sterilization	
		Per cent
4.5	4.6	10.08
5.0	5.1	18.25
5.5	5.4	34.62
6.0	5.6	40.86
6.5	6.0	42.84
7.0	6.7	46.43
7.5	6.9	45.60
8.0	7.1	45.82
8.5	7.4	44.87
9.0	7.55	42.12

* Cabbage-enriched Leuconostoc medium was adjusted at different pH.

Influence of incubation temperature on dextran production.—The temperature at which microorganisms are allowed to grow influences their growth and metabolism. Mentioned ahead is the result of previous tests wherein the cabbage organism produced the highest quantity of dextran in the modified Leuconostoc medium without cabbage extract, at incubation temperature of 20°C, but yields were irregular. It has also been demonstrated in Table 1, that 10 per cent cabbage extract added to the basal medium stimulated the organism to produce 46.06 per cent dextran also at 20°C. To ascertain that this result was not due to the stimulatory effect of the cabbage extract alone, the influence of temperature on dextran formation was retested.

Several test tubes of cabbage-enriched Leuconostoc medium were inoculated with a 2-day-old organism and incubated at different temperatures: 7, 12, 17, 20, 25, 27, and 28 to 30°C (room temperature). After 2 days, the pH and dextran produced by the organism were determined.

As shown in Table 3, when cultures of the organism in the cabbage-enriched Leuconostoc medium were incubated at different temperatures, the yield of dextran, was 12.15 per cent at 7°C, increased to 34.18 at 12°, reached the maximum of 46.33 per cent at 20° and decreased as the temperature was raised, the yield being only 17.01 per cent at 28 to 30° (room temperature). The variation in the yields of dextran at different temperatures appears to be a function of temperature and not of pH since the cultures had the same initial pH of 6.7. It could not also be attributed to the acids formed during fermentation as the pH of the 2-day-old cultures incubated at different temperatures did not deviate materially from pH 4. The results of the experiments corroborate previous observation on the temperature optimum of 20°C for dextran formation by the *Leuconostoc* under study.

TABLE 3.—*Dextran production at different incubation temperatures in Cabbage-enriched Leuconostoc medium with initial pH 6.7.*

Temperature	Results of 2 days' fermentation	
	pH	Dextran
°C		*Per cent*
7	4.2	12.15
12	3.9	34.18
17	4.0	43.01
20	4.0	46.33
25	4.0	41.87
27	4.1	25.23
28–30 (room temp.)	4.1	17.01

Effect of age of inoculum on dextran synthesizing ability of the organism.—An inoculum was prepared in a cabbage-enriched Leuconostoc medium. Every day, for 10 days, transfers were made from this inoculum. In all cases, the transfers were allowed to ferment for 2 days at 20°C before running quantitative determinations for the dextran formed. Repeated tests consistently gave highest yields of dextran from cultures originating from a 2-day-old inoculum.

Duration of fermentation and dextran yields.—To determine whether the quantity of dextran formed by the cabbage organism is increased as the fermentation period is varied, several tubes of cabbage-enriched Leuconostoc medium pH 6.7 were inoculated and incubated at 20°C. Every day, cultures were taken for dextran and pH determinations.

The amount of dextran obtained from the cultures was 41.42 per cent, after one day of fermentation, as seen in Table 4. The maximum yield, 46.01 per cent, was produced on the second day, and was gradually but slightly reduced as the culture grew older reaching 43.13 per cent after 7 days. The reduction in the quantity of dextran as the cultures became older is in conformity with the findings of Palo and Lapuz(19) in their study of dextran formation by *Streptococcus crystalloides*, Palo and Lapuz. These authors believe that the decrease in the dextran might be due to some hydrolytic enzyme affecting the dextran or to gradual acid hydrolysis of the gum due to the increase in acid produced. It was noted that the amount of acid produced increased when the incubation period was prolonged as shown by the lowering of the pH from 4.1 after one day of fermentation to 3.7 after 7 days.

TABLE 4.—*Dextran yields at different fermentation periods in cabbage-enriched Leuconostoc medium with initial pH 6.7.*

Period of incubation	Results of 2 days' fermentation	
	pH	Dextran
Days		*Per cent*
1	4.1	41.42
2	3.8	46.01
3	3.9	45.98
4	3.9	45.62
5	3.6	44.09
6	3.6	44.40
7	3.7	43.13

Nature of carbohydrate and suitable concentration for dextran formation.—Carruthers and Cooper(10) and Baens-Arcega and Yenko(5) have demonstrated that dextran can be synthesized by *L. dextranicum* from glucose liberated from sucrose by the organism itself and not from free glucose. The concentration of sucrose used by these authors was 10 per cent.

To ascertain the suitable concentration of the carbohydrate for dextran production by the organism, under study, test tubes containing cabbage-enriched Leuconostoc medium of varying strengths of sucrose: 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, and 20.0 per cent were inoculated. Tubes containing cabbage-enriched Leuconostoc medium without carbohydrate and several with 10 per cent glucose instead of sucrose were also inoculated. All the inoculated tubes were incubated at 20°C for 2 days.

Table 5 shows that the highest yield of dextran by weight (7.716 g/100 cc culture) was obtained from the 20 per cent sucrose concentration showing 38.58 per cent utilization of sucrose. The same table shows the highest percentage (59.44) for sucrose conversion into dextran occurred in the 2.5 per cent sucrose concentration but the yield by weight (1.486 g/100 cc culture) was the lowest. For an economical and convenient concentration of sucrose, 10 per cent was the highest that gave maximum conversion into dextran, 46.78 per cent which is almost theoretical (47.37 per cent).

TABLE 5.—*Carbohydrate source of dextran and its suitable concentration in the medium.*

Carbohydrate in medium	Concentration of carbohydrate	Initial pH of medium	pH of 2-day-old culture	Yield of dextran after 2 days of fermentation	
	Per cent			*Grams*[3]	*Per cent*[4]
none	0.0	6.4	6.4	none	none
Sucrose[1]	2.5	6.5	3.7	1.486	59.44
Do	5.0	6.5	3.5	2.637	52.74
Do	7.5	6.5	3.7	3.285	43.80
Do	10.0	6.6	4.0	4.678	46.78
Do	12.5	6.5	4.1	5.735	45.88
Do	15.0	6.6	4.0	6.273	41.82
Do	17.5	6.5	4.1	7.660	43.77
Do	20.0	6.5	4.1	7.716	38.58
Dextrose[2]	10.0	6.4	4.2	none	none

[1] Amount of sucrose in cabbage-enriched Leuconostoc medium was varied to obtain different concentrations of sucrose (2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, and 20.0 per cent).

[2] Dextrose was used as carbohydrate material instead of sucrose in cabbage-enriched Leuconostoc medium.

[3] Computed on the basis of 100 cc of culture.

[4] Percentage yield of dextran was based on the weight of sucrose used.

In the medium where no carbohydrate was added, dextran was not formed. In the medium where dextrose was substituted for sucrose, dextran was not also formed. The failure of the organism to convert glucose into dextran conforms with the findings of previous investigators(5, 10) that dextran is formed by species of *Leuconostoc* only from nascent dextrose liberated from sucrose by the organism itself.

Continuous subculturing of the cabbage organism at intervals of two days in liquid medium and its effect on dextran formation.—To determine whether continuous subculturing of the cabbage organism in liquid medium has some effect on dextran formation, a 2-day-old inoculum on agar slant was transferred into six test tubes of cabbage-enriched medium, labelled "transfer No. 1," and incubated at 20°C. At the end of 2 days fermentation, "transfer No. 1" served as inoculum for "transfer No. 2." At the same time three tubes of 2-day-old cultures of "transfer No. 1" were taken for dextran determinations. The series of subsequent transfers in liquid medium, incubation at 20°C and dextran determinations of the 2-day-old cultures was continued until 35 transfers were made.

As shown in Table 6 the cabbage organism did not easily reduce its power to produce dextran by subsequent transfers in liquid medium. The highest yields of dextran, 45.79 to 46.53 per cent, obtained from transfers 1 to 3 gradually decreased on further transfers. The amount started to fall below 40 per cent from transfer No. 26. In transfer No. 35 the dextran obtained was only 25.14 per cent. The efficiency of the organism to form dextran was restored by culturing it in agar plates before it was transferred again to liquid medium.

TABLE 6.—*Showing a series of transfers of the cabbage organism at 2-day intervals in cabbage-enriched Leuconostoc medium and its effect on dextran formation.*

Transfer No.	Dextran formed after 2 days' fermentation	Transfer No.	Dextran formed after 2 days' fermentation
	Per cent		*Per cent*
1	45.79	19	40.09
2	46.53	20	41.06
3	45.98	21	41.36
4	43.19	22	41.62
5	42.25	23	42.02
6	42.10	24	41.52
7	41.25	25	40.88
8	41.82	26	38.38
9	43.55	27	38.84
10	42.04	28	39.33
11	42.26	29	37.02
12	41.95	30	36.65
13	43.51	31	32.06
14	43.50	32	32.65
15	43.43	33	31.80
16	41.86	34	29.65
17	41.14	35	25.14
18	40.11		

Fermentation of sugars.—Test on the fermentation of different sugars by the cabbage organism was carried as follows:

One liter of basal medium, without sucrose and cabbage extract, containing 1 cc of bromthymol blue indicator was sterilized at 15 lbs of steam pressure for 30 minutes, then allowed to cool. The medium was measured in 150 cc volumes into 6 sterilized Erlenmeyer flasks, five of which contained separately 0.75 gram of the test sugars, and the last one without sugar.

Each test medium was distributed in 20 cc volumes into graduated Smith fermentation tubes and sterilized in Arnold Steam Sterilizer for 30 minutes' duration for 3 consecutive days. Three tubes containing a test sugar were inoculated with the organism. Uninoculated tubes containing test sugar and inoculated tubes without sugar served as checks for the experiments.

After 2 days of fermentation, the color of the solutions changed from blue to yellow in the tubes where acids were produced. The blue color remained unchanged in solutions where no acids were formed.

As indicated in Table 7, acids were produced in the inoculated fermentation tubes containing pentose sugars (arabinose, rhamnose, and xylose) as well as in those containing hexose sugars (dextrose and levulose). Acids were not produced in uninoculated tubes containing the test sugars and in the inoculated tubes without test sugar. Dextran was not formed in any of the fermentation tubes.

TABLE 7.—*Fermentation of pentose and hexose sugars.*

Sugar	Treatment	Reaction after 2 days	Dextran formation
No-sugar	Uninoculated	No change	None
	Inoculated	No change	do
Arabinose	Uninoculated	No change	do
	Inoculated	Acidic	do
Rhamnose	Uninoculated	No change	do
	Inoculated	Acidic	do
Xylose	Uninoculated	No change	do
	Inoculated	Acidic	do
Dextrose	Uninoculated	No change	do
	Inoculated	Acidic	do
Levulose	Uninoculated	No change	do
	Inoculated	Acidic	do

DESCRIPTION OF THE CABBAGE ORGANISM

Agar colonies—When the gum-forming organism is plated in cabbage-enriched Leuconostoc medium containing 2 per cent agar and incubated at 20°C, growth is visible after 2 days. The colonies (Plate 1) are smooth-edged, circular with base diameter of 4.5 mm, convex with height of 1.1 mm, mucoid and transparent. Growth is so fast that nearby colonies coalesce readily and form large ones.

Morphological characteristics.—A smear prepared from a suspension of a 24-hour-old cabbage organism and stained with carbol fuchsin shows spheroidal cells occurring mostly in pairs, some in groups and occasionally in chains. Individual cells (Plate 2, fig. 1) have an average measurement of 0.27 micron long and 0.18 micron wide. Smear prepared from a suspension of a 3-day-old organism (cultured in agar medium and incubated at 20°C), stained with carbol fuchsin and reliefed with nigrosine solution shows pairs, short chains and groups of tiny cells enclosed within thick capsules (dextran) indicated by white hollows in Plate 2, fig. 2. The capsules have an average length of 6.3 microns and width of 4.8 microns.

SPECIFIC IDENTITY

The dextran-forming organism under study is smaller compared with those of same species described in literature, but based on the cultural and morphological characteristics, on the slime formation from sucrose and on the biochemical reactions with sugars, the cabbage organism in question is properly placed under the genus *Leuconostoc.*

Hucker and Pederson, according to Bergey's Manual of Determinative Bacteriology,(7) recognize only three species belonging to the genus *Leuconostoc: L. mesenteroides* (Cienkowski) Van Tieghem; *L. dextranicum* (Beijerinck) Hucker and Pederson and *L. citrovorum* (Hammer) Hucker and Pederson. According to their fundamental physiological characters, only *L. citrovorum* does not produce slime from sucrose. Both *L. mesenteroides* and *L. dextranicum* form slime from sucrose and vary slightly in cultural and morphological characteristics. But *L. mesenteriodes* ferments both sucrose and pentose sugars, a secondary physiological characteristic that constantly distinguishes it from *L. dextranicum* which ferments only sucrose but fails to ferment pentose sugars.

The cabbage organism, under study, besides forming slime from sucrose, fermented both pentose (arabinose, rhamnose and xylose) and hexose (dextrose and levulose) sugars as shown in Table 7.

In view of the foregoing considerations, the cabbage organism is identical with *Leuconostoc mesenteroides* (Cienkowski) Van Tieghem, henceforth it will be referred to as such.

SUMMARY

Dextran-forming microorganisms were isolated from fermenting Philippine fruits, vegetables, and other plant parts. Of the 32 isolates, that from cabbage was selected for study due to its efficiency for producing dextran from sucrose.

The gum produced by the cabbage isolate is soluble in water and when hydrolyzed with dilute acid, yields a dextrorotatory substance which reduces Fehling's solution indicating the presence of dextrose.

The organism produces almost a theoretical yield of dextran in two days when incubated at 20°C in a cabbage-enriched Leuconostoc medium (pH 6.7) containing 10 per cent sucrose, peptone, yeast extract some salts and cabbage extract as a source of stimulatory factor for dextran formation.

Organism originating from 2-day-old inoculum is most active for production of dextran.

Ten per cent sucrose added to nutrient medium is most convenient and economical concentration for maximum conversion into dextran equivalent to 46.78 per cent on the sucrose used.

Successive transfers of the cabbage organism in liquid medium gradually weaken its dextran-forming efficiency, which may be restored by culturing it in agar before transferring it into liquid medium again.

The cabbage organism fermented both pentose (arabinose, rhamnose, xylose) and hexose (dextrose and levulose) sugars.

A brief description of the cultural and morphological characteristics of the organism is given.

Based on the observed morphological and cultural characteristics and on the fermentation reactions on pentose and hexose sugars, the cabbage organism has been identified as *Leuconostoc mesenteroides* (Cienkowski) Van Tieghem.

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REFERENCES

1. Anonymous. Dextran as a blood plasma substitute. Sugar 47 (1952) 37.

2. Anonymous. Dextran Degradation. East Anglia Chem. Co. Ltd. Brit. 650,783. March 7, 1951. Cited in Chem. Abstr. 45 (1951) 6798.
3. Anonymous. PVP and dextran near commercial production as blood substitutes. Chem. Eng. News 29 (1951) 650–654.
4. ARRHENIUS, ANNA. Some experiments with Leuconostoc mesenteroides. Int. Sugar Jour. 48 (1946) 269–271.
5. BAENS-ARCEGA, LUZ, and FLAVIANO M. YENKO. Some factors affecting the production of dextran from cane sugar by Leuconostoc dextranicum. Philip. Jour. Sci. 77 (1947) 39–53.
6. BIXLER, GORDON H., G. E. HINES, R. M. MC GHEE, and R. A. SHURTER. Dextran. Ind. Eng. Chem. 45 (1953) 692–705.
7. BREED, ROBERT S., E. G. D. MURRAY, and A. PARKER HITCHENS. Bergey's Manual of Determinative Bacteriology. 6th Edition. The William and Wilkins Co., Baltimore, Md. (1948) xvi + 1529 pp.
8. BURKE, Wm. E. Dextran for National Defense. Sugar 48 No. 11 (1953) 50–1. Cited on Chem. Abstr. 48 (1954) 1038.
9. CARLSON, WHITESIDE, and WARNER W. CARLSON. Enzymatic hydrolysis of dextran. Science 115 (1952) 43.
10. CARRUTHERS, A., and E. A. COOPER. Biochem. Jour. 30 (1936) 1001.
11. HARRISON, HAROLD J. Dextran as a plasma substitute with plasma volume and excretion studies on control patients. Ann. Surg. 139 (1954) 137–42. Cited in Chem. Abstr. 48 (1954) 4688.
12. HARTMAN, FRANK W. Fate and Disposal of plasma substitute. Ann. N. Y. Acad. Sci. 55 (1952)) 504–12. Cited in Chem. Abstr. 47 (1953) 1855.
13. HILDEBRANDT, FRITZ. Dextran as a blood plasma substitute. Arztl. Wochschr. 5 (1950) 141–3. Cited in Chem. Abstr. 47 (1953) 7107.
14. INGLEMAN, B. Dextran and its use as blood plasma substitute. Acta Chem. Scand. 1 (1947) 731–8. Cited in Chem. Abstr. 43 (1949) 3914.
15. JEANES, ALLENE. Dextran. A selected bibliography. U. S. Dept. Agric. Bur. Agri. Ind. Chem. AIC 288 (1950) 13 pp., 136 references.
16. JEANES, A., C. A. WILLIAM and J. C. MIERS. Fermentation production and chemical characterization of the B-512 dextran. Jour. Biol. Chem. 176 (1948) 603.
17. LUNDY, JOHN S., HOWARD K. GRAY, and WINCHELL MCK CRAIG. Dextran in supportive therapy, with comments on periston and gelatin. Cited in Chem. Abstr. 44 (1950) 8531.
18. MAHONEY, J. C. Comestible and process for preparing same. U. S. Pat. 2,089,217. Aug. 10, 1937.
19. PALO, MACARIO A., and MARTINA M. LAPUZ. On a new gum-forming streptococcus, with studies on the optimal conditions for the synthesis of the gum and its production in coconut water. Philip. Jour. Sci. 83 (1954) 327–357.
20. RENFREU, ALICE G., and L. H. CRETCHER. Partially hydrolyzed dextran Jour. Amer. Pharm. Assoc. 38 (1949) 177–79.
21. RICKETTS, C. R., L. LORENZ, and W. d'A. MAYCOCK. Molecular composition of dextran solutions for intravenous use. Nature 165 (1950) 770–1. Cited in Chem. Abstr. 44 (1950) 8597.

22. RUSSELL, KENNETH L., and MANNO F. NESON, Jr. U. S. Pat. 2,779,708 Jan. 29, 1957. Cited in Chem. Abstr. **51** (1957) 60.
23. TURNER, FENNEL P., BYRON C. BUTLER, MARGARET E. SMITH, and JOHN SCUDDER. Dextran, an experimental plasma substitute. Surg. Gynecol. Obstet. **88** (1949) 661–75.
24. UNDERKOFLER, LELAND A., and RICHARD J. HICKEY. Industrial Fermentation. Vol. 2. Chemical Publishing Co., Inc., New York, N. Y. (1954) ix + 578 pp.
25. WADSWORTH, D. V., and M. F. HUGHES. Sugar sirup and process. U. S. Pat. 2,409,816 Oct. 22, 1946.
26. WHITE, WILLIAM H. Safer substitutes for blood plasma. Science Digest **34** (1953) 23–8.
27. WHITESIDE-CARLSON, VIRGINIA and WARNER W. CARLSON. The vitamin requirements of Leuconostoc for dextran synthesis. Jour. Bact. **58** (1949) 135.

ILLUSTRATIONS

[Photographs by C. S. Angbengco]

PLATE 1

A 2-day-old agar plate culture of *Leuconostoc mesenteroides,* isolated from Philippine cabbage, which was incubated at 20°C, showing circular, transparent, mucoid, smooth edged and convex colonies; about × 1.

PLATE 2

FIG. 1. Photomicrograph of stained cells from a 24-hour-old culture of *L. mesenteroides* in liquid medium. Spheroidal cells occur mostly in pairs, some in groups and occasionally in chains; about × 1,600.

2. Photomicrograph of a smear taken from a 3-day-old culture of *L. mesenteroides* on agar slant, incubated at 20°C. The smear was stained with carbol fuchsin and reliefed with nigrosine solution. Tiny cells enclosed within a thick capsule of dextran are indicated as white hollows; about × 1,600.

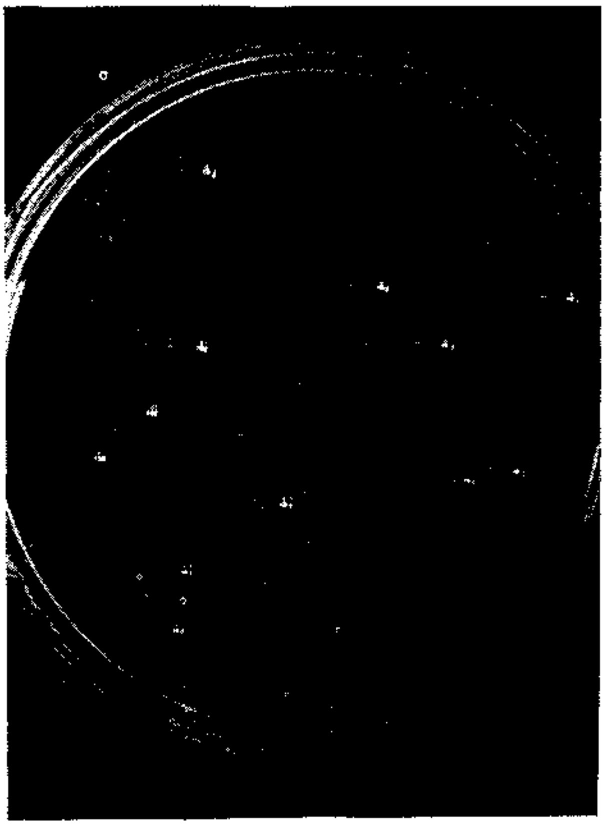
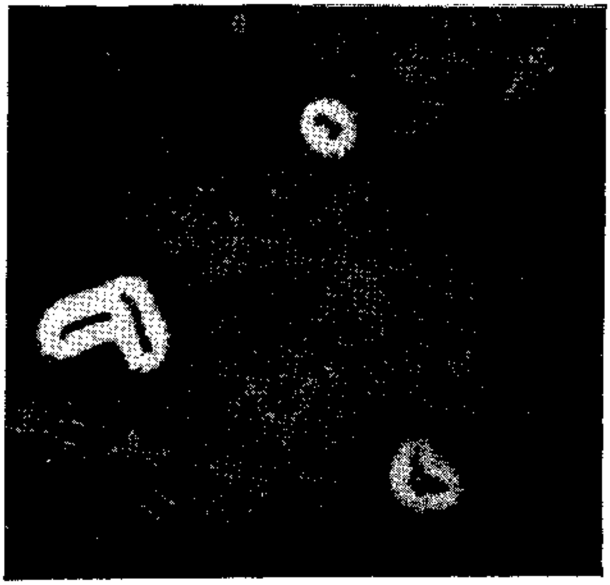


PLATE 1.

1



2

PLATE 2.

PHILIPPINE SPECIES OF XESTOCEPHALUS VAN DUZEE (CICADELLIDÆ, HOMOPTERA) IN THE BAKER COLLECTION, UNITED STATES NATIONAL MUSEUM

By Santiago R. Capco
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SIX TEXT FIGURES

On my visit to the United States National Museum in August, 1955, Dr. David Young, Jr., entomologist and in charge of leafhoppers, U.S. National Museum, suggested to me that the genus *Xestocephalus* be further studied as this group, according to him, is still imperfectly known in the Orient, especially in the Philippines. All the materials of the genus were loaned to me by the proper authorities of the Museum. There was not sufficient time while abroad to make such study possible, so I made arrangements to take these materials home, to Manila, and these form the basis for this report. The internal male genitalia were examined to supplement the color and color markings commonly used in distinguishing the species in the genus. Most of the structural characters are generic in nature.

Merino (4) listed four species for the Philippines, two species of which were described as new. In Japan, Ishihara (3) listed five species, including *X. guttatus*, which is also represented in the Philippines. Of the six species reported in the present paper, four were included by Distant.(1, 2)

XESTOCEPHALINÆ

Tribe XESTOCEPHALINI

GENUS XESTOCEPHALUS Van Duzee, 1892

Xestocephalus Van Duzee, Trans. Amer. Ent. Soc. 19 (1892) 209; Distant, Faun. Brit. Ind. Rhyn. 4 (1908) 348.

Type: *X. pulicarius* Van Duzee, 1894, a Nearctic species, by subsequent designation by Distant (1908).

Small but robust leafhoppers; head narrower than pronotum; vertex with apical margin roundly produced, wider than long, eyes in line with lateral margins; clypellus short, relatively broad, constricted near base; pronotum wider than long, convex, anterior margin rounded, lateral margins short; tegmina with small appendices or absent; seventh sternum of female small, sclerotized dorsally to a very narrow band; ædeagus narrowly U-shaped, sometimes with paired basal processes on shaft; connective somewhat cruciform, arms short; style long, apex enlarged and boot-shaped.

Distribution: Distant(1) gave the distribution as Nearctic, Eastern Palæarctic, Ethiopian, and Oriental Regions; Oman(5) stated that members of this or a very closely allied genus are known from all geographical regions of the world.

Key to the Philippines species of Xestocephalus[1]

[Based on the male internal genitalia.]

1. Shaft of ædeagus with two basal processes 2
   Shaft of ædeagus without basal processes 3
2. Boot-shaped apex of style with the outer margin bent sideward and serrated .... *apicalis* Melichar
3. Boot-shaped apex of style with margin not bent sideward and not serrated 4
4. Boot-shaped apex of style with heel-shaped margin at base 5
   Boot-shaped apex of style without such margin 6
5. Heel-shaped margin at base wide; apex straight towards pointed tip. *osborni* Merino
   Heel-shaped margin at base narrow and pointed; apex curved inward towards pointed tip .... *paganurus* Melichar
6. Apex short, outer margin convex and inner margin almost straight. *maquilingensis* Merino
   Apex long, outer margin straight and suddenly curved inward towards pointed tip, inner margin slightly curved .... *relatus* Distant

XESTOCEPHALUS APICALIS Melichar. Fig. 1.

Xestocephalus apicalis MELICHAR, Hom. Faun. Ceylon (1903) 207; DISTANT, Faun. Brit. Ind. Rhyn. 4 (1908) 249–350.

Length 3.0 millimeters.

Shiny fulvous throughout, eyes black, legs yellow; tegmina with grayish-brown markings, apical area with a small dark-brown spot, a round opaque milk-white spot on costal margin at about middle area, other characters as in the genus.

Male genitalia distinct; ædeagus U-shaped, with a pair of processes near base; style long and slender, boot-shaped apex with outer margin bent sideward and serrated.

LUZON: Laguna Province, Mt. Maquiling, C.F. Baker (Baker Collection, U.S. Nat. Museum), represented by many specimens.

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[1] *X. guttatus* Motschulsky was included in the key because no male specimen in good condition was available when the study was made.

Laguna Province, Mt. Maquiling, P. C. Feliciano, January 14, 1954; Mountain Province, Trinidad, March 4, 1954, S. R. Capco; Rizal Province, Pateros, December 10, 20, 30, 1953, January 5, 1954, S. R. Capco (all in the Bureau of Plant Industry Collection).

Distribution.—Ceylon, Philippines.

This species is reported for the first time from the Philippines.

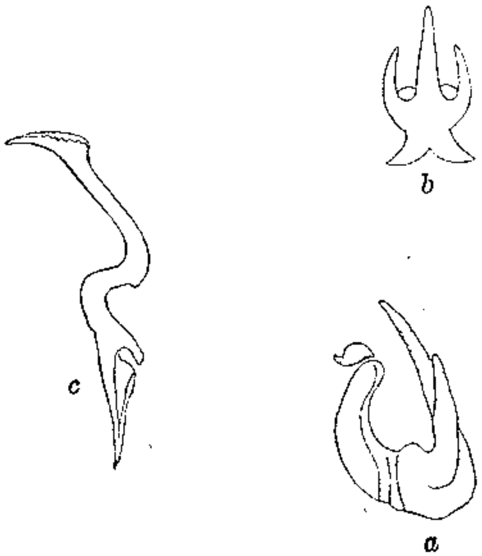

FIG. 1. *Xestocephalus apicalis* Melichar: *a*, ventral view of ædeagus; *b*, side view of ædeagus; *c*, side view of style.

XESTOCEPHALUS GUTTATUS Motschulsky.

Xestocephalus guttatus MOSTCHULSKY, Etud. Ent. (1859) 113 (Deltocephalus); MATSUMURA, Termesz Fuzetex 25 (1903) 403 (Xestocephalus); MELICHAR, Hom. Faun. Ceylon (1903) 306, Pl. 5, fig. 82, a, b; WIEN, Ent. Zeit. 24 (1905) 303; DISTANT, Faun. Brit. Ind. Rhyn. 4 (1908) 349; MERINO, Philip. Jour. Sci. 61 (1936) 396.

This is the smallest species of the genus in the Philippines. It measures about 2 millimeters, fulvous with some irregular pale spots.

No male specimen was available for dissection.

LUZON: Laguna Province, Los Baños, C. F. Baker. MINDANAO: Agusan Province, Butuan. BASILAN. C. F. Baker (Baker Collection, U. S. Nat. Mus.).

Distribution.—Ceylon, Japan, East Africa, and Philippines.

XESTOCEPHALUS MAQUILINGENSIS Merino. Figs. 2, 3.

Xestocephalus maquilingensis MERINO, Philip. Jour. Sci. 61 (1931) 387, Pl. 2, fig. 9, a. b. c.

Length, 2.2 to 2.5 millimeters.

The specimens on hand was chocolate-brown with light fulvous markings; tegmen brown, with transparent fulvous spots, a large faint milky-white spot on middle costal marginal area.

Male genitalia distinct; ædeagus U-shaped, without processes at base; style small, boot-shaped apex short and without heel-shaped basal margin, outer margin convex, inner margin almost straight pointed at tip.

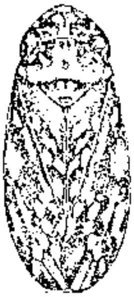

FIG. 2. Dorsal view of Xestocephalus *maquilingensis* Merino. ♂. (X-36).

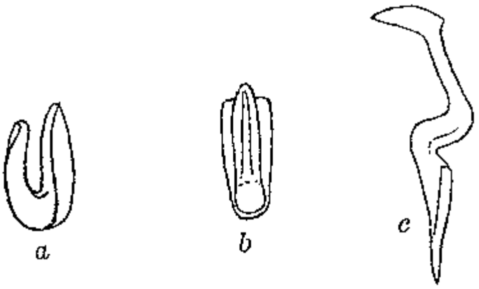

FIG. 3. *Xestocephalus maquilingensis* Merino: *a*, side view of ædeagus; *b*, ventral view of ædeagus; *c*, side view of style.

LUZON: Laguna Province, Los Baños, Mt. Maquiling, C.F. Baker (Baker Collection, U.S. Nat. Mus.).

Distribution.—Philippines.

XESTOCEPHALUS OSBORNI Merino. Fig. 4.

Xestocephalus osborni MERINO, Philip. Jour. Sci. 61 (1936) 386–387, Plate 2, fig. 6, a. b. c. d.

Length, 3.5 to 4 millimeters.

Fulvous, with ochraceous spots on pronotum and lateral angles of scutellum, tegmen with irregular ochraceous cross markings, faintly visible in some specimens.

Male genitalia distinct; ædeagus long and slender, U-shaped, without processes at base, apex tapering towards pointed tip; style strongly curved at middle, boot-shaped apex with a wide heel-shaped basal margin, apex straight, tip pointed.

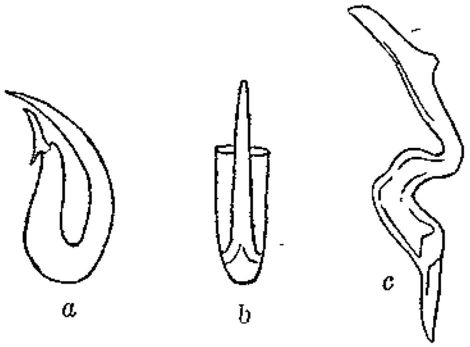

FIG. 4. *Xestocephalus osborni* Merino: *a*, side view of ædeagus; *b*, ventral view of ædeagus; *c*, side view of style.

LUZON: Laguna Province, Mt. Maquiling, C. F. Baker; Mountain

Province, Baguio, C. F. Baker; Nueva Vizcaya Province, Imugan, C. F. Baker. MINDANAO: Agusan Province, Butuan, C. F. Baker (Baker Collection, U. S. Nat. Mus.).

Distribution.—Philippines.

XESTOCEPHALUS PAGANURUS Melichar. Fig. 5.

Xestocephalus paganurus MELICHAR, Hom. Faun. Ceylon (1903) 207; DISTANT, Faun. Brit. Ind. Rhyn. 7 (1918).

Xestocephalus pardalinus DISTANT, Faun. Brit. Ind. Rhyn. 4 (1908) 350; MERINO, Philip. Jour. Sci. 61 (1936) 396.

Length 3.8 millimeters.

Vertex brown, with 2 discal castaneous spots; pronotum castaneous with eight light-brown spots; scutellum brown, lateral spots castaneous; tegmina grayish brown with castaneous markings; abdomen and legs ochraceous, posterior tibiæ spotted with brownish black.

Male genitalia distinct; ædeagus U-shaped, stout at base and without processes, tip of apex rounded; style large, long, boot-shaped apex with a narrow pointed heel-shaped margin at base, apex curved inward toward pointed tip.

LUZON: Laguna Province, Los Baños, Mt. Maquiling, C. F. Baker. MINDANAO: Agusan Province, Butuan, C. F. Baker; Zamboanga del Norte Province, Dapitan, C. F. Baker (Baker Collection, U. S. Nat. Mus.).

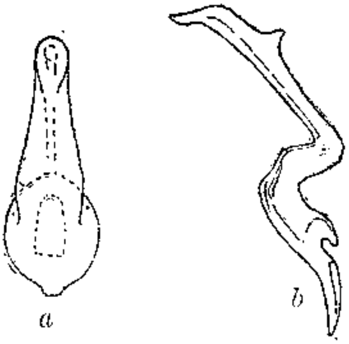

FIG. 5. *Xestocephalus paganurus* Melichar: *a*, ventral view of ædeagus; *b*, side view of style.

Distribution.—Ceylon, Philippines.

This species was included by Merino(4) in his "Philippine Cicadellidæ," as *pardalinus* Distant without any data beyond mention of Baker's Collection.

XESTOCEPHALUS RELATUS Distant. Fig. 6

Xestocephalus relatus DISTANT, Faun. Brit. Ind. Rhyn. 7 (1918) 54.

Length, 3.5 millimeters.

Head, pronotum, scutellum, tegmina, ochraceous; similar to *apicalis* but without the milky-white spots on the tegmina.

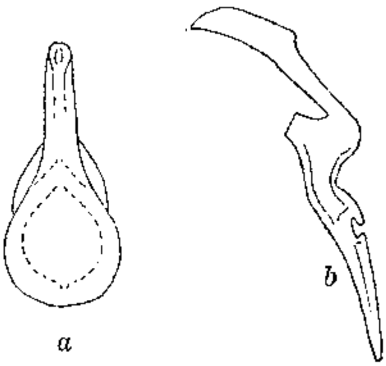

FIG. 6. *Xestocephalus relatus* Distant: *a*, ventral view of ædeagus; *b*, side view of style.

Male genitalia distinct; ædeagus U-shaped, without basal processes, base stout, apex slender, rounded at tip; style long, slightly curved, boot-shaped apex long, without heel-shaped margin at base, outer margin straight and suddenly curved inward towards pointed tip, inner margin slightly curved.

LUZON: Laguna Province, Bay, Los Baños, Mt. Maquiling, C. F. Baker; Mountain Province, Baguio, C. F. Baker. MINDANAO: Agusan Province, Butuan, C. F. Baker; Davao Province, Davao, C. F. Baker; Lanao Province, Iligan, C. F. Baker (Baker Collection, U. S. Nat. Mus.).

Distribution.—India, Philippines.

This species is reported for the first time from the Philippines.

REFERENCES

1. DISTANT, W. L. Fauna British India including Ceylon and Burma. Rhynchota 4. London: Taylor and Francis (1908) xv + 501, figs. 1–282.
2. DISTANT, W. L. Fauna British India including Ceylon and Burma. Rhynchota 7. London: Taylor and Francis (1918) viii + 210, figs. 1–90.
3. ISHIHARA, T. A tentative list of the superfamily Cicadelloidea of Japan (Homoptera). Sci. Rept. Matsuyama Agr. Coll. 11 (1953) 1–73, Plates 1–17.
4. MERINO, G. Philippine Cicadellidæ (Homoptera). Philip. Jour. Sci. 61 (1936) 307–399, Plates 1–4.
5. OMAN, P. W. Nearctic Leafhoppers. (Homoptera, Cicadellidæ), a generic classification and check list. Mem. Ent. Soc. Wash. 3 (1949) ii + 353, 44 plates.

THE PHILIPPINE SPECIES OF SIMULIUM (DIPTERA, SIMULIIDÆ)

By Mercedes D. Delfinado
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FOUR PLATES AND ONE TEXT FIGURE

F. W. Edwards[1] reported two forms of Philippine *Simulium*, one of which he described as new, *S. melanopus;* the other, he believed to be *S. aureum* Fries. Except for this brief report, there has been no record of any work on this group of insects.

In a subsequent paper,[2] dealing with Javanese and Sumatran *Simulium*, Edwards introduced a new arrangement in which all Oriental species having the front tarsi distinctly flattened and enlarged were placed under Group I, subgroup B. He assigned the Philippine *S. melanopus* to this group subgroup.

I was able to borrow the specimen Edwards thought was *S. aureum.* A re-examination of this material has convinced me that it is not *aureum.* It is described in the present paper as new species: *S. philippinensis.*

The Institute of Malariology has now a fairly good collection of *Simulium.* These specimens were taken from various sections of the Philippines, mostly as part of the general mosquito collections undertaken in connection with the nation-wide malaria control project. Several of these seem to be new and undescribed forms, but only four of them are well represented by specimens. These are treated in the present paper. Three of them are considered new. The other forms must await more material before they can be properly studied.

Separation of species is based on adult characters primarily, but whenever known or available, characters of the pre-imaginal stages are also used. Of the adults the principal diagnostic differentiation is supplied by the structure of the front tarsi, supplemented by the peculiarities of the mouth parts and the terminalia. The number of the respiratory organs of the pupæ, as well as the structure of the mentum and head pattern of the larvæ, also appear to be very useful. For the parts of the male terminalia, the terms used by Freeman[3] are adopted.

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[1] Edwards, F. W. Not. Ent. Helsing. **9** (1929) 1–14.

[2] Deutsche Limnologische Sunda-Expedition. Arch. Hydrobiol. Suppl. **13** (1934) 92–138.

[3] Freeman, P. Ann. Trop. Med. Parasit. **44** (1950) 146–152.

The present study is based mainly on the material obtained from carabao-baited traps and on adults that emerged from pupæ collected from rapidly flowing, lowland streams. Most of the specimens studied are in the collection of the Division of Malaria at Tala. The others were lent by Prof. Richard Frey, of the Museum Zoologicum Universitatis, Helsingfors, Finland. The types are in the collection of the Division of Malaria at Tala.

ACKNOWLEDGMENT

Sincere thanks are due to Prof. Richard Frey for lending type specimens from his collection at Museum Zoologicum Universitatis, Finland, and to Mr. Paul Freeman, of the British Museum (Natural History), London, for making conparisons of specimens. Mr. R. H. Wharton, of the Institute of Medical Research, Malaya, and Dr. I. M. Mackerras, of the Queensland Institute of Medical Research, Australia, were very helpful in sending photostat references needed in the study. The illustrations in this publication are the work of Mr. Eliseo Enriquez.

Key to the Philippines species of Simulium Latreille

FEMALES

1. Front tarsi distinctly flattened, enlarged; tibiæ with silvery dusting on anterior side; frons shining, black; propleura, anterior pronotal lobe, and upper mesepimeral area with fine, black hairs; basal half of radius bare 2

   Front tarsi elongate, subcylindrical; tibiæ without silvery dusting; frons dull, gray dusted; propleura, anterior pronotal lobe and upper mesepimeral area with patch of fine silvery hairs; radius hairy all over 3

2. Claws simple, without sub-basal tooth; antenna blackish-brown basally, black apically .... *melanopus* Edwards

   Claws each with a sub-basal tooth; antenna yellowish brown, except for black apical 2 segments .... *baltazaræ* sp. nov.

3. Antenna entirely yellow; mesonotal lines indistinct; lower sternopleural area bare; last 3 tergites dull .... *philippinensis* sp. nov.

   Antenna yellow at basal third or more, brown apically; with three distinct mesonotal lines; lower sternopleural area with golden hairs; last 3 tergites distinctly shining .... *baisasæ* sp. nov.

SIMULIUM MELANOPUS Edwards.

Simulium melanopus EDWARDS, Notulae Ent. Helsing **9** (1929) 13. Type: Male, Mount Banahao; Paratype: Mount Data, Luzon (Museum Zoologicum Universitatis).

Female.—Wing 2.07 mm long. Frons shining, black; pubescence black, fine and scanty; frons about 0.13 mm at its narrowest point; clypeus gray-dusted, pubescence black, upright, rather scanty; antenna about 0.42 mm long, brownish black at basal third, black apically, though in some specimens the antenna is entirely black; basal segments distinctly broader than long, tapering towards tip; palpi black, about 0.43 mm long, sensory vesicle on basal half of third segment small; posterior pharyngeal armature (Plate 4, fig. 5) very characteristic, consisting of several rows of small blunt denticles; roof of pharynx smooth; maxillary teeth evenly large, 12 on each side; apical margins of mandible evenly serrated. Thorax black. Mesonotum considerably shiny all over, gray dusting slightly distinct; pubescence golden, uniformly distributed, scanty, rather dense towards scutellum. Pleura blackish gray-dusted; hairs on anterior pronotal lobe, propleura and upper mesepimeral area black, fine and rather few; membranous area and lower sternopleural area bare. Legs mainly black. Middle and hind coxæ black, front coxæ and trochanters brownish; femora black, except front femora which are brownish at extreme base; tibiæ black, with silvery dusting on outer side, hind tibiæ somewhat yellowish at extreme base; front tarsi entirely black, first three segments broadly flattened; middle and hind basitarsi pale yellow at basal two-thirds or more; base of second and ventral half of fourth segments of middle tarsi somewhat pale. Wings hyaline; stem vein brownish black; hairs and spines black; radius bare at basal half. Halteres yellow at knob, stem brownish black. Abdomen black, last four tergites brightly shining. Second tergite with silvery gray dusting, tergites 3 to 5 velvety black. Genital fork strongly chitinized, rather thick, stem about 0.18 mm long, arm divergent; anterior gonapophyses dark, rather short and somewhat produced posteriorly into a blunt point, inner margins straight and gently rounded anteriorly, narrowing or closing posteriorly; hairs short, less dense; paraprocts produced posteriorly into a sharp point, with rather short, sparse hairs; cerci short, about 2.5 times as broad as long; spermatheca sub-spherical, a membranous duct at apex. (Plate 2, figs. 16 and 17)

Male.—The following description is based on the type lent by Prof. Frey, the only available material.

Holoptic. Head black, broader than thorax; large facets of eyes extending down to antenna; mouthparts black; scape of antenna brownish black (flagellum missing); clypeus with distinct silvery gray dusting; pubescence long, black, upright and rather few. Thorax velvety or dull black above, pubescence scanty, somewhat golden. Mesonotum with large silvery crescent-shaped areas on shoulders, shining when viewed from in front, broadly silvery shining when viewed from behind; sides silvery shining. Pleura gray dusted, membranous area bare; hairs on propleuron, anterior pronotal lobe and upper mesepimeral area black, rather few. Scutellum black and shining, its marginal hairs black; postscutellum somewhat gray-dusted shining. Legs as in female except for the much flattened hind basitarsi. Wings with basal part of radius bare. Halteres brownish black. Abdomen velvety black. Fringe on first tergite more brownish than black. Second tergite silvery gray-dusted; fifth tergite with a small silvery patch at extreme base; tergite 6 to 8 with large shining sub-lateral patches, somewhat iridescent-greenish on 8. Hypopygium (Plate 3, fig. 11). A camera lucida sketch from a paratype by Mr. Paul Freeman, British Museum (Natural History). Diststyle longer than basistyle, widest near base, bearing a single, large spine at tip; ventral plate narrow; parameral hooks small, all equal in size.

Specimens examined.—LUZON: 3 females (collected from carabao-baited traps), Pilar, Sorsogon, December, 1955, W. Santos (Division of Malaria at Tala); male (type), Mt. Banahaw, Luzon, June, 1914; female (paratype), Mt. Data, Luzon, March, 1917 (both type and paratype are in the Museum Zoologicum Universitatis at Finland).

SIMULIUM BALTAZARÆ sp. nov.

Female.—Wing about 2.16 mm long. Frons, vertex and occiput black, shining; pubescence black, scanty. Clypeus (face) silvery gray-dusted, longer than broad, hairs fine and black. Narrowest width of frons, about 0.14 mm, widened strongly above antenna. Antenna 11-segmented, about 0.54 mm long, segments distinctly broader than long; yellowish brown except for black apical two segments. Palpi long, about 0.6 mm long; basal two segments short, sub-equal; third segment large and swollen, about twice as long as broad; fourth segment as long as third but narrower; fifth segment long and slender, about 2.5 times the length of third; dark brown except for yellow basal two segments; sensory vesicle on middle of third sub-elongate. Pharynx (Plate 4, fig. 10) with distinct posterior armature consisting of 3 to 4 rows of large, sharp denticles; roof of pharynx with minute projections; apical margins of mandible distinctly serrate, pointed, maxillary teeth large, about 23, 11 to 12 on each side. Thorax black. Mesonotum somewhat gray-dusted, considerably shining; pubescence fine, black; scutellum black, with long, black hairs on its posterior margin. Pleura blackish, gray-dusted, more or less shining; anterior pronotal lobe, propleura, and upper mesepimeral area with few black hairs; prealar (membranous) area and lower sternopleural area bare. Legs long and thickest, covered with flat hair (at least the middle and hind femora and tibiæ), denser in male. Front coxæ yellow, middle and hind black; trochanters except for dark apical half of middle; femora black except for yellowish-brown ventral front; front tarsi entirely black; first three segments distinctly flattened, enlarged; middle and hind tarsi mainly yellowish; middle tarsi except for the last segment and the second to the fourth segments of hind tarsi darkened at tip; tarsal segments of middle and hind legs black; basal two-thirds of hind basitarsi and pedisulcus yellow. First and third segments of fore and hind tarsi with a pair of extremely long apical black hairs. Hind basitarsi distinctly long, about twice the length of the following four segments together or slightly longer. Calcipala well developed, reaching the depth of pedisulcus. Claws with distinct subbasal tooth. Wings (Plate 1, fig. 1) hyaline, base dark, hairs and spines black; basal half of radius anterior to the fork bare. Halteres yellow at knob and stem, base dark. Abdomen black; tergites rather broad, last three broader, brightly shining; pubescence black; scanty; black fringe on first tergite long, short at middle; second tergites shining, silvery gray-dusted; third, fourth, and fifth tergites velvety black. Stem of genital fork about 0.17 mm long, arm widened, sclerotized; anterior gonopophyses produced posteriorly into a blunt point, with conspicuous long hairs, their inner margins slightly wide, curving close towards each other posteriorly and somewhat swollen; paraprocts long, pointed posteriorly and bearing long hairs; cerci short, with posterior margin rounded; spermatheca subspherical, its end giving rise to a membranous duct. (Plate 4, figs. 5 and 6.)

Male.—Similar to female. Wing about 2.04 mm long. Holoptic. Head black, distinctly broader than thorax; large facets of eyes extending down to antenna, slightly wider than diameter of antennal sclerite. Clypeus silvery gray-dusted; pubescence black and upright. Antenna about 0.48 mm long; third segments about twice as long as broad and slender. Palpi about 0.57 mm long and slender; sensory vesicle on third segment rather small. Thorax silvery gray-dusted, shining. Mesonotum with an inverted V-shaped transverse velvety black band at middle; scutellum velvety black with the usual long, black hairs at posterior margin; postscutellum somewhat shiny, silvery gray-dusted. Hairs fine and black rather few on anterior pronotal lobe and upper mesepimeral area. Legs densely covered with flat hairs, at least on middle and hind; coloration as in female. Wings with the basal half of second radial sector bare. Knob of halteres yellow, large, its stem black. Abdomen black with broad tergites. Second tergite silvery white, shining; tergites 4 to 7 with sublateral silvery white patches, rather large on 6 and 7; tergites 3, 8, and 9 velvety black; pubescence black, rather dense. Hypopygium (Plate 3, figs. 1 to 5). Diststyle longer than basistyle, widest near base, narrowing towards tip, bearing a single, large, sharp spine; basistyle sub-quadrate; ventral plate (Plate 3, figs. 2 and 3) narrow, Y-shaped, dentate margin of median process projecting ventrad beyond dentate portion; parameral hooks rather large, sub-equal.

Pupa.—(Plate 1). Length 2.0 to 3.0 mm long. Mainly pale brown except for blackish brown thorax. Respiratory organ (Figure 8) with 10 branches. Filaments rather short, about the length of thorax; dorsal two pairs of filaments with long petiole, strongly diverging upward from the other six filaments; ventral outer pair of filaments with a very short petiole, parallel along most of their length with the median filaments which are sessile and arising almost from a common base and arranged in one plane. Filaments slender, more or less thick at base, gradually tapering towards tip. Trichomes of thorax small, rather indistinct. Fourth and fifth abdominal segments with a row of four short, stout, retrose hooks on each middorsal side; rest of segments smooth, without such spines. Ventral segments with a pair of median bifid spines on 8 and two trifid spines on 6 and 7; on 6 segment, the spines are very closely approximated, on 7 and 8 segments widely separated. Apical hooks absent.

Cocoon.—(Plate 1, figs. 7 and 9). Shoe or boot-shaped, with narrow anteroventral closure; texture smooth, finely woven; opening wide, without mid-dorsal projection.

This species closely resembles *S. melanopus* Edwards, but differs in having an almost entirely black antenna; in the female, the posterior pharyngeal armature consists of several rows of small, blunt denticles, and there are differences as pointed out in the details of the male genitalia.

Type.—Female (collected as pupa, with associated pupal skin and cocoon), LUZON: Molawin Creek, College, Laguna, February 22, 1958, M. D. Delfinado (Division of Malaria at Tala).

Paratypes.—Four females, 1 male, same data as type; NEGROS: 2 females, Bais, Negros Oriental, February 6, 1956, A. de Jesus; SAMAR: 2 females, Nato, January 19, 1956, I. Balatbat (all are in the Division of Malaria at Tala); 2 females, 2 males same data as type; MINDANAO: 3 females, Malaybalay, Bukidnon, October 6, 1956, M. Simbulan; 2 females, Malaybalay, Bukidnon, October 6, 1956, M. Simbulan (U. S. National Museum); 2 females, Malaybalay, Bukidnon, October 6, 1956, M. Simbulan (Museum Zoologicum Universitatis, Helsingfors, Finland).

Named in honor of Dr. Clare R. Baltazar, entomologist, Bureau of Plant Industry, Manila.

SIMULIUM BAISASÆ sp. nov.

Female.—Small, brown to black species. Wing about 1.74 mm long. Frons, vertex and occiput dull black, gray-dusted; pubescence dense, forming bare line at middle of frons, broad, narrowing towards antenna, about 0.12 mm at its narrowest point; clypeus (face) dull, distinctly gray-dusted, its pubescence dense, golden and rather coarse. Antenna 11-segmented, 0.39 mm long; first segment short, second hemispherical, third twice as long as broad, the rest of the flagellar segments about as long as broad; yellowish at basal third, dark brown apically; palpi about 0.43 mm long, slender, basal two segments short, almost equal in length, third segments moderately enlarged, sensory vesicle elongate, fourth segment clavate, about two-thirds length of fifth, which is long and slender, palpi tricolorous, basal two segments pale yellow, third segment dark brown, except for pale apex, last two segments pale brown. Postero-ventral margin of pharynx (Plate 4, fig. 15) smooth, without armature; apical margin of mandible pointed, distinctly serrate; maxillary teeth 18 to 21, 9 to 12 on either side. Thorax brownish black. Mesonotum dull gray-dusted with three distinct reddish black, lyre-shaped longitudinal lines, median line narrow, laterals wider posteriorly and curved;

pubescence golden, uniformly distributed on surface; scutellum with dark fine hairs on its posterior margin; pleura blackish gray with silvery reflection; membranous area bare; propleuron, anterior pronotal lobe and upper mesepimeral area with patch of soft, fine silvery hairs; lower sternopleural area with few scattered golden hairs. Legs mainly brown. Flat hairs on middle and hind femora and tibiæ less dense. Front coxæ brown, middle and hind yellowish; trochanters yellowish; femora yellowish brown, hind coxæ distinctly dark at apical third, rather variable in intensity; tibiæ dark towards apex, hind tibiæ angulate, distinctly broad at apical half; front tarsi dark brown, elongate, with an apical pair of long hairs at anterior surface of segments 1 and 3; basal half of middle basitarsi, basal two-thirds of hind basitarsi and whole of pedisulcus pale yellowish. Claws simple, without subbasal tooth. Calcipala well developed, reaching beyond the deep of pedisulcus. Wings (Plate 1, fig. 2) hyaline, brown at base; veins pale, except the anterior ones which is brown; hairs golden, spines dark brown, radial sector hairy all over. Halteres pale at knob, stem brown. Abdomen dark brown to black, tergites rather small. Fringe on first tergite short at middle, golden; tergite 5 rather broad, more or less shining; tergites 6 to 8 broad, distinctly shining, pubescence golden and less dense. Stem of genital fork 0.15 mm long, each arm widened, weakly sclerotized, darkened at apex; anterior gonapophyses short, inner apical angle not produced, inner margins straight, widely divergent; paraprocts short, broadly produced ventrally; cerci short, posterior margin rounded, about twice as broad as long; spermatheca subovoid, its end giving rise to a membranous duct (Plate 2, figs. 20 and 21).

Male.—Similar to female, but darker and smaller. Wing about 1.56 mm long. Holoptic. Head markedly broader than thorax. Clypeus somewhat dull, without silvery gray dusting, its pubescence golden and upright; upper facets of eyes extremely large, about the diameter of antennal sclerite, in about 12 to 13 rows. Antenna about 0.38 mm long, slender, tapering toward tip, yellowish brown at basal half, gradually turning brown towards tip. Palpi about 0.44 mm long, third segment long, about three times as long as broad, the rest of flagellar segment about as long as broad. Sensory vesicle on third segment small. Thorax black; mesonotum gently rounded, velvety black; pubescence golden, denser and coarser on anterior and lateral margins, on prescutellar area and scutellum, the latter somewhat shining and gray-dusted. Pleura as in female but hairs on anterior pronotal lobe and propleural area appearing more golden than silvery. Mesonotal lines indistinct. Legs mainly black, covered with dense flat hairs on at least middle and hind femora and tibiæ. Hind femora distinctly swollen; hind tibiæ more angulate. Pale areas as in female. Abdomen black. Tergites velvety black, except for silvery and conspicuously shining second tergite and sub-lateral sides of abdominal segments 5 to 9. Silvery patches on tergites 5 and 6 extensive, thus reducing black areas to small median isolated area. Hairs long and dense, fringe on first tergite extremely long and golden. Wings as in female, with the radial sector uniformly hairy. Halteres yellow at knob, stem black. Hypopygium (Plate 3, figs. 6 to 10). Dististyle shorter than basistyle, about four times as long as broad bearing a single, short spine at tip; ventral plate (Plate 3, figs. 7 and 8) broad, rectangular, with a moderately produced median process and apical margin convex, uniformly hairy, basal arm well developed; parameral structures each with three distinct large teeth and several smaller ones.

Pupa (*Plate 1*).—Length 2.0 to 2.5 mm long. Mainly brown. Respiratory organ (Fig. 5) with six branches, arranged in pairs, all equally long, about as long as pupa; dorsal pair of filaments slightly diverging upward from the other two pairs; petiole long, ususally twice as long as broad; petiole of median pair slightly shorter than or about as long as dorsal pair, directed somewhat laterad; petiole of third pair usually short, directed somewhat mediad; filaments slender, moderatly thick at base, gradually tapering toward tip. Trichomes on head and thorax few, indistinct. Third abdominal segments with six minute spines dorsally; fourth and fifth abdominal segments with a row of four short, stout, retrose hooks on each side of the middorsal line; segments 7 to 10 with a row of triangular spines near anterior margin. Ventral segments 7 to 9 with a pair of bifid spines on either side of mid line. Spines of 7, closely approximated, submedian in position; widely separated on segments 8 and 9. Apical hooks small, directed backward.

Cocoon (*Plate 1, figs. 4 and 6*).—Well formed, rather loosely woven with some visible individual threads. Wall pocket-shaped, with irregular middorsal anterior projection; ventral wall incomplete, covering only the abdomen.

Larva.—Full grown about 5.0 mm long. Body creamy or greenish, irregularly mottled with darker patches. Head dark; pattern on dorsum and lateral sides variable in intensity, often as in Fig. 1*a*. Antenna with four distinct segments, almost of equal length except a minute terminal fourth. Mentum (Fig. 1,*d*) with four or five hairs on either side, median tooth very prominent. Ventral excavation (Fig. 1,*c*) small, reaching

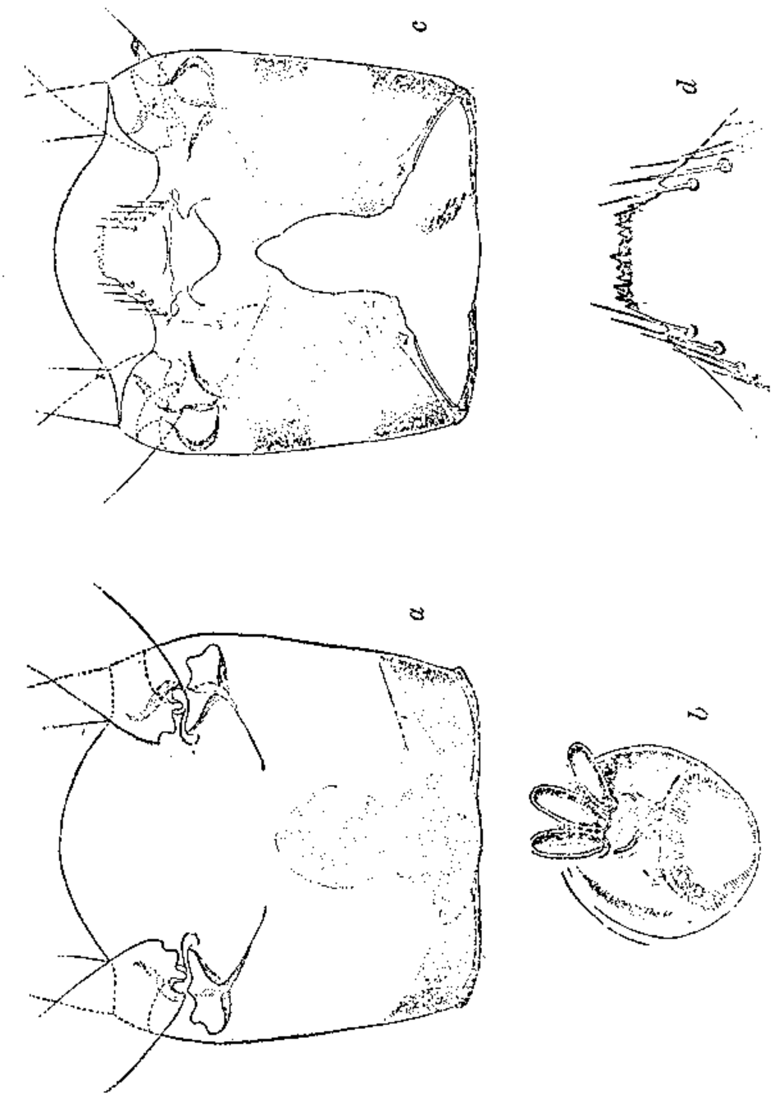

FIG. 1. Larva of S. *baisasae* sp nov.: *a*, dorsal view of head showing pattern; *b*, rectal gills; *c*, ventral view showing ventral excavation and pattern; *d*, mentum.

only halfway to mentum. Mouth fans each with forty-three to forty-five rays, weakly pectinate. Gill spot large, black, posteriorly coiled. Posterior circlet consisting of several rows of spines. Rectal gills (Fig. 1,*b*) consisting of three simple digtations. Last abdominal segment with a pair of conical ventral tubercles.

Type.—Female (collected as pupa, with associated pupal skin and cocoon), LUZON: Molawin Creek, College, Laguna, February 22, 1958, M. D. Delfinado (Division of Malaria at Tala).

Paratypes.—LUZON: 4 females, 4 males, same data as type, mounted on slides; 2 females, Tala, Rizal, March 19 and 28, 1956, E. Enriquez; 2 females, Tala, Rizal, February 17, 1956 and October 19, 1955, M. D. Delfinado; 2 males, Tala, Rizal, April 16, 1956, E. Enriquez (all in the Division of Malaria at Tala); 2 males, Tala Rizal, March 9, 1956, F. E. Baisas; male, female, Tala, Rizal, September 23, 1957, M. D. Delfinado (Museum Zoologicum Universitatis). 3 females, 6 males (2 mounted on slides), same data as type (U. S. National Museum).

The name is in honor of Mrs. Josefina Calingo-Baisas, whose husband has contributed much to our knowledge of Philippine Culicidæ.

SIMULIUM PHILIPPINENSIS sp. nov.

A large species with conspicuosly marked black and yellow legs and entirely yellow antenna.

Female.—Wing, 2.11 mm long. Frons, vertex, occiput dull black, gray dusted; pubescence recumbent, rather scanty, appearing more silvery than golden; frons greatly narrowing towards antenna, about 0.09 mm at its narrowest point; clypeus (face) dull black, distinctly gray dusted pubescence dense, somewhat golden. Mouthparts black; palpi dark, about 0.54 mm long; third segment swollen, sensory vesicle large at middle, fourth segment about twice the length and width of fifth; antenna about 0.42 mm, entirely yellow, segments broader than long, broadest at third. Posteroventral margin of pharynx smooth; apical margin of mandible somewhat rounded, evenly serrated; maxillary teeth large, about 19, 9 to 10 on either side. Scutum velvety black, brownish at shoulders, gray dusting rather indistinct; mesonotal lines indistinct; pubescence black, uniformly distributed, scanty, somewhat denser and coarser toward scutellum; marginal hairs on scutellum long and golden. Pleura dull grayish; anterior pronotal lobe, propleura and upper mesepimeral area with patch of golden hair, upright on anterior pronotal lobe and upper mesepimeral area, coarser and recumbent on propleura; lower sternopleural and prealar (membranous) areas bare. Front coxæ yellow, middle and hind blackish on outer side; trochanters, entire front femora, basal two-thirds of middle and hind femora yellow; hind femora distinctly large, broadened at apical half; front tibiae yellow, black at apical third or more, darkened at outer basal half; middle and hind tibiae black at apical third or more and with black sub-basal ring; tarsi black, except for yellowish white basal half of hind basitarsi and pedisulcus; front tarsi enlarged, cylindrical, segments 1 and 3 with the usual long hairs at tip and above; claws with a stout basal projection, at least half length of claw. Wings hyaline; veins pale except for brown anterior and stem veins; hairs golden, spines black; radial sector hairy all over. Halteres with knob and stem yellow, base brown. Abdomen velvety black, except as follows: base of first and entire second tergites brownish, tergites 6 to 8 dull brown, and tergite 9 somewhat shining at posterior margin; pubescence dense, golden; fringe on first tergite short, fine and golden. Stem of genital fork about 0.16 mm long, arm widened, rather weakly sclerotized; anterior gonapophyses short, not produced, pale with short, less dense hairs; inner margins straight, wide and parallel along most of their length; cerci subovoid with seven conspicuous long hairs posteriorly, about 2.5 times as broad as long; paraprocts small, short, not produced; spermatheca, subspherical, its end giving rise to a short sclerotized duct (Plate 2, figs. 22 and 23).

Male.—Similar to female in most characters, except as follows: Wing about 1.82 mm long. Antenna with basal half of second and tenth segments, and apical half of ninth segments brownish; marginal hairs on scutellum golden; pleura brownish black with patch of fine, golden pubescence on upper mesepimeral and propleural areas. Spines and hairs on anterior veins of wing black. Knob of halteres yellow, stem brown. Legs densely covered with black and golden hairs; coloration as in female. Abdomen with velvety black tergites, densely covered with coarse golden hairs. Fringe on first tergite extremely long and golden. Diststyle broad, about 1.5 times as long as broad, rather flat, parallel sided, bearing a large spine at tip;

basistyle conspicuously large, swollen at base; ventral plate (Plate 3, figs. 13 and 15) broad, with ventrally directed median process strongly developed but never with dentate margin; uniformly setose on most of ventral surface; parameres each with three hooks.

Pupa and larva unknown.

Type.—LUZON: female, collected from light trap, Tala, Rizal, May 21, 1958, M. D. Delfinado (Division of Malaria at Tala).

Paratypes.—Male, same data as type. LUZON: female, Clark Air Base, Angeles, Pampanga, September 17, 1957, I. Balatbat (U. S. National Museum); female, Clark Air Base, Angeles, Pampanga, September 17, 1957, I. Balatbat (Museum Zoologicum Universitatis); female, Clark Air Base, Angeles, Pampanga, September 8, 1957, I. Balatbat (Division of Malaria at Tala), all collected from light traps.

ILLUSTRATIONS

PLATE 1

[Wing showing detail of anterior wing veins.]

FIG. 1. Female *S. baltazaræ.*
2. Female *S. baisasæ.*
3. Male *S. baisasæ.*

[Pupa and cocoon of *S. baisasæ.*]

4. Ventral view of cocoon.
5. Dorsal and ventral views of pupa showing respiratory organ and spination.
6. Lateral view of cocoon.

[Pupæ and cocoon of *S. baltazaræ*]

7. Ventral view of cocoon.
8. Dorsal and ventral views of pupa showing respiratory organ and spination of body.
9. Lateral view of cocoon.

PLATE 2

[Legs of female and male (front, mid, and hind), with detail of claw (lateral), apex of hind tibia showing vestiture, and basitarsus showing calcipala and pedisulcus.]

FIG. 1–3. Female *S. philippinensis.*
4–6. Female *S. baisasæ.*
7–9. Male *S. baisasæ.*

[Legs of female (front, mid, and hind), with detail of claw and apex of hind tibia and basitarsus.]

10–12. *S. melanopus.*
13–15. *S. baltazaræ.*

[Ventral view of female terminalia; lateral view of paraproct and cercus.]

16–17. *S. melanopus.*
18–19. *S. baltazaræ.*
20–21. *S. baisasæ.*
22–23. *S. philippinensis.*

PLATE 3

[Male genitalia. Ventral view of entire genitalia, with right basistyle and dististyle removed to show parameral structures and ventral plate. Lateral and end views of ventral plate and lateral and dorsal views of dististyle, except for *S. melanopus*, are also shown.]

FIG. 1–5. *S. baltazaræ.*
6–10. *S. baisasæ.*
11. *S. melanopus* [a camera lucida sketch from a paratype by Mr. Paul Freeman, British Museum (Natural History).]
12–15. *S. philippinensis.*

PLATE 4

[Female antenna, maxillary palpus showing detail of sensory vesicle, apex of mandible and maxilla and posterior margin of pharynx.]

1– 5. *S. melanopus* Edwards.
6–10. *S. baltazaræ* sp. nov.
11–15. *S. baisasæ* sp. nov.
16–20. *S. philippinensis* sp. nov.

TEXT FIGURES

FIG. 1. Larva of *S. baisasæ* sp. nov.: *a*, dorsal view of head showing pattern; *b*, rectal gills; *c*, ventral view of head showing ventral excavation and pattern; *d*, mentum.

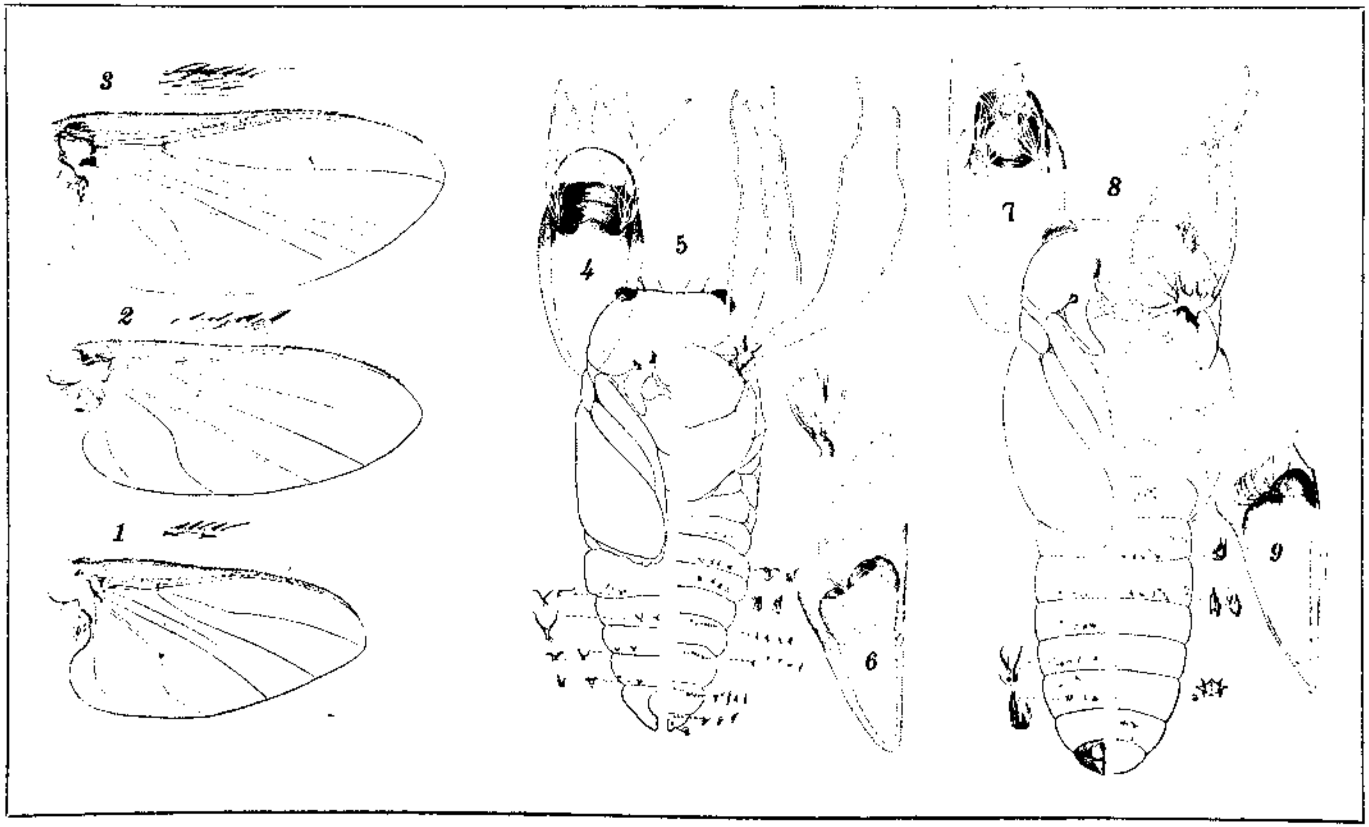

PLATE 1.

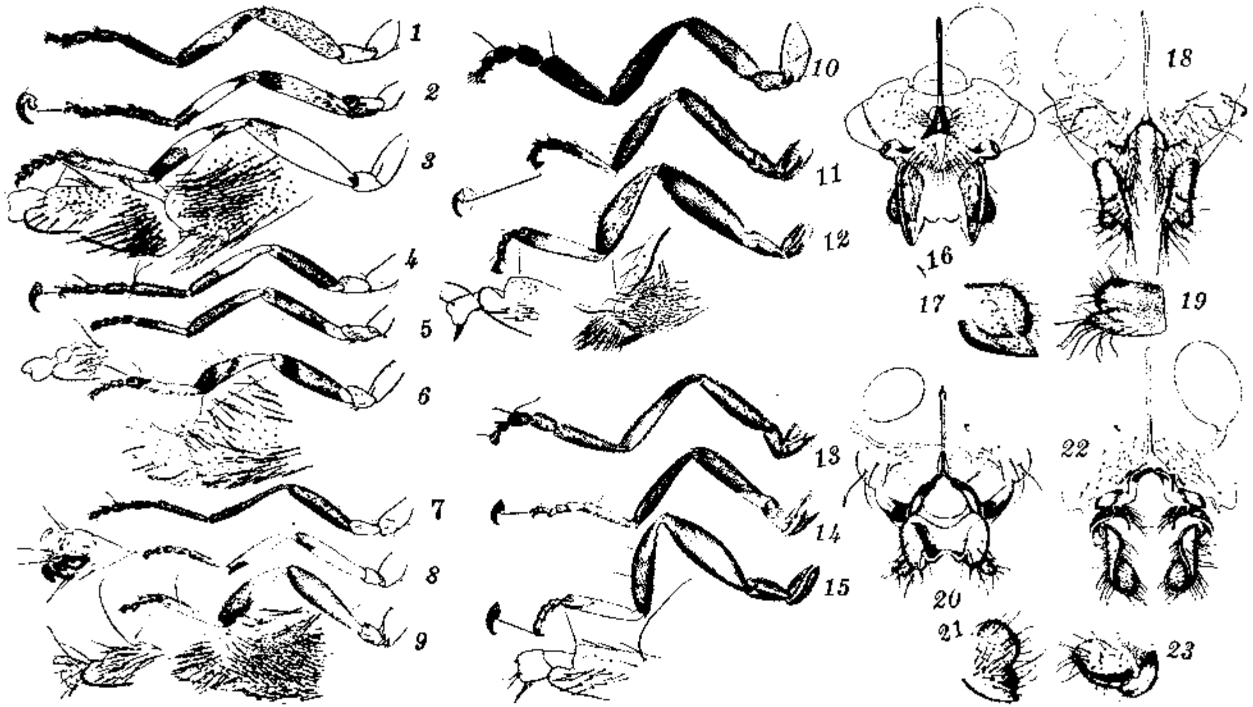

PLATE 2.

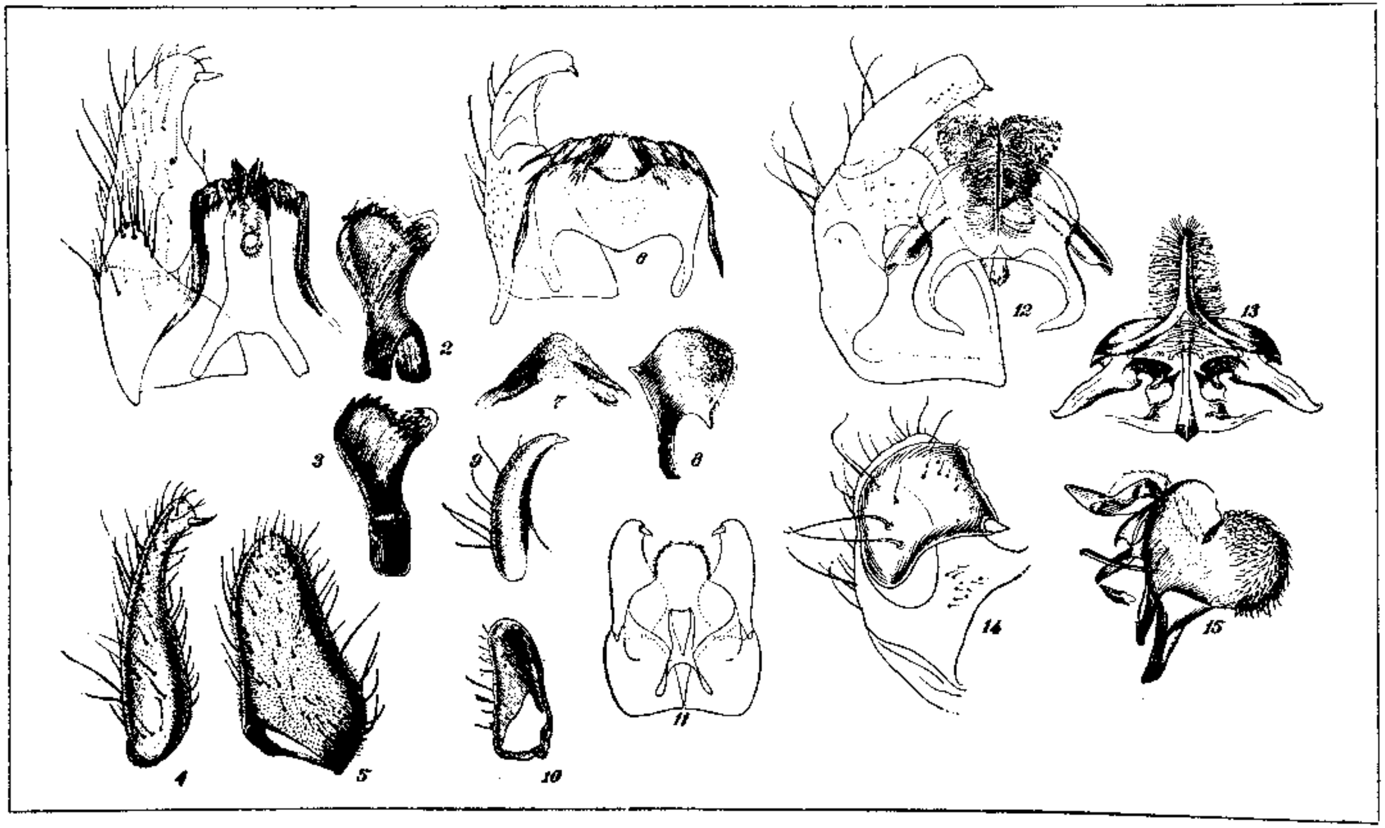

PLATE 3.

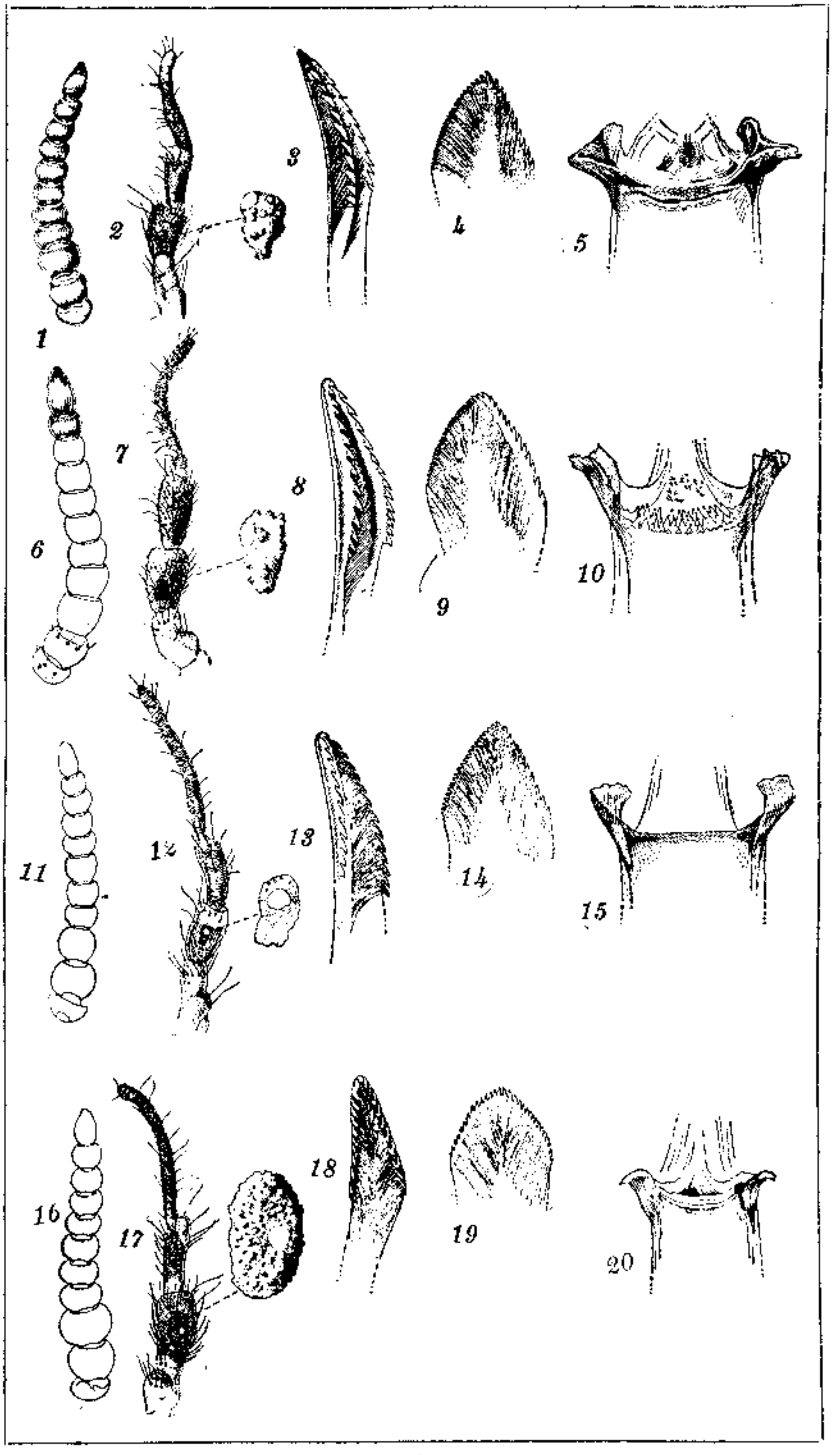

PLATE 4.

A SUMMARY OF PHILIPPINE TERMITES WITH SUPPLEMENTARY BIOLOGICAL NOTES

By THOMAS E. SNYDER[1] and FAUSTINO C. FRANCIA[2]

Fifty-four species of termites, in eighteen genera, are known from the Philippines and doubtless new species will be discovered. The genus *Nasutitermes* is represented by the largest number with twenty species and the genus *Neotermes* is next with five species. The remaining genera are each represented by one to three species. Some of the species injure living trees and crops, others the woodwork of buildings. S. F. Light described many of these termites; his keys have been utilized and his notes have been drawn upon in compiling the latter part of this article.

In this paper, the Philippine termites are listed and identification keys to winged adults and soldiers are presented. Some species are known only from winged adults, others from the soldier caste. The notes on the habits of some species were furnished by the junior author. Technical terms used in the keys are explained in the Appendix.

LIST OF KNOWN PHILIPPINE TERMITES

KALOTERMITIDÆ

1. *Kalotermes mcgregori* Light
2. *Kalotermes taylori* Light
3. *Neotermes grandis* Light
4. *Neotermes lagunensis* (Oshima)
5. *Neotermes malatensis* (Oshima)
6. *Neotermes microphthalmus* Light
7. *Neotermes parviscutatus* Light
8. *Cryptotermes cyanocephalus* Light
9. *Cryptotermes dudleyi* Banks
10. *Glyptotermes chapmani* Light
11. *Glyptotermes franciæ* Snyder
12. *Glyptotermes magsaysayi* Snyder

RHINOTERMITIDÆ

1. *Heterotermes philippinensis* (Light)
2. *Coptotermes flavicephalus* Oshima

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[2] Entomologist, Forest Products Research Institute, College, Laguna, Philippines.

3. *Coptotermes vastator* Light
4. *Prorhinotermes gracilis* Light
5. *Prorhinotermes tibiaoensis* (Oshima)
6. *Schedorhinotermes bidentatus* (Oshima)
7. *Schedorhinotermes longirostris* (Brauer)
8. *Schedorhinotermes tarakanensis* (Oshima)

TERMITIDÆ

1. *Microcerotermes distans* (Haviland)
2. *Microcerotermes los-banosensis* (Oshima)
3. *Microcerotermes philippinensis* Ahmad
4. *Capritermes paetensis* (Oshima)
5. *Macrotermes gilvus* (Hagen)
6. *Odontotermes* (*Odontotermes*) *dives* (Hagen)
7. *Odontotermes* (*Odontotermes*) *paradenticulatus* Ahmad
8. *Nasutitermes balintauacensis* (Oshima)
9. *Nasutitermes brevicornis* Light and Wilson
10. *Nasutitermes busuangæ* Light
11. *Nasutitermes castaneus* (Oshima)
12. *Nasutitermes chapmani* Light and Wilson
13. *Nasutitermes constricticeps* Light and Wilson
14. *Nasutitermes culasiensis* (Oshima)
15. *Nasutitermes latus* Light and Wilson
16. *Nasutitermes luzonicus* (Oshima)
17. *Nasutitermes mariveles* (Light and Wilson)
18. *Nasutitermes mcgregori* (Oshima)
19. *Nasutitermes meridianus* Light and Wilson
20. *Nasutitermes mindanensis* (Light and Wilson)
21. *Nasutitermes mollis* Light and Wilson
22. *Nasutitermes oshimæ* Light and Wilson
23. *Nasutitermes panayensis* (Oshima)
24. *Nasutitermes parvus* Light and Wilson
25. *Nasutitermes rotundus* Light and Wilson
26. *Nasutitermes simulans* Light and Wilson
27. *Nasutitermes taylori* Light and Wilson
28. *Havilanditermes atripennis* (Haviland)
29. *Grallatotermes admirabilus* Light
30. *Grallatotermes splendidus* Light and Wilson
31. *Lacessititermes holmgreni* Light and Wilson
32. *Lacessititermes palawanensis* Light
33. *Hospitalitermes hospitalis* (Haviland)
34. *Hospitalitermes luzonensis* (Oshima)

Key to known termites of the Philippines based on the winged adults

1. Fontanelle or head gland absent; no subsidiary tooth at base first marginal tooth right mandible; forewing scale usually not much longer than pronotum; branches between costal and subcostal veins 2.

Fontanelle usually present; subsidiary tooth at base first marginal tooth right mandible; forewing scale definitely longer than flat pronotum; no branches between costal veins .... 7.

Fontanelle usually present with plate; forewing scale shorter than saddle shaped pronotum; no branches between costal veins .... 11.

2. Median vein heavy, close to costal vein .... 3.
Median vein light, free from costal veins .... *Kalotermes*
Median vein light, usually united with subcostal vein near middle of wing .... 6.

3. Wing membrane stippled; antenna with 12 segments; small species, 7 mm in length .... *Glyptotermes chapmani* Light.
Larger species, 8.2 mm in length, antenna with 13 segments.
Glyptotermes magsaysayi Snyder.
Wing membrane clear; large species, over 15 mm in length .... 4.

4. Eye very small; 3rd antennal segment chitinized, twice as long as 4th; hairs long, color dark red-brown.
Neotermes microphthalmus Light.
Eye larger; 3rd antennal segment not as chitinized, less than twice as long as 4th; hairs shorter 5

5. Larger, head 2.16 mm in width; dark brown.
Neotermes parviscutatus Light.
Smaller, head 1.5 mm in width; castaneous.
Neotermes malatensis (Oshima).

6. Length 8 mm .... *Cryptotermes cyanocephalus* Light.
Length 9 to 10 mm .... *Cryptotermes dudleyi* Banks.

7. Median vein absent; wing margin not ciliate, clypeus swollen but not produced, without distinct median groove; fontanelle distinct; color Light .... 8.

8. Yellow-brown .... *Prorhinotermes tibiaoensis* (Oshima).
Darker brown .... *Prorhinotermes gracilis* Light.
Median vein present; wing membrane ciliate, clypeus not swollen or produced, usually flat; color light .... 9.

9. Ocelli lacking; antennæ with 15 to 17 segments; wing membrane punctate .... *Heterotermes philippinensis* (Light).
Ocelli present; antennæ with 18 to 23 segments, wing membrane reticulate .... 10.

10. Head yellow, ocellus not close to eye; length 13 mm.
Coptotermes flaviccphalus Oshima.
Head darker; ocellus close to eye; length 11.5 mm.
Coptotermes vastator Light.
Clypeus produced, directed forward, with distinct median groove; color dark .... *Schedorhinotermes tarakanensis* (Oshima).

11. Very large species 20 to 26 mm in length .... 12.

12. Subsidiary tooth at base first marginal tooth right mandible; wings clear brown, third segment antenna as large as second.
Macrotermes gilvus (Hagen).
Subsidiary tooth absent; wings smoky brown; third antennal segment smaller than second .... *Odontotermes* (*O.*) *dives* (Hagen).

13. Medium-sized to small species, never more than 20 mm in length; tibiæ with two apical spines; soldiers nasute .... 14.
Fore tibiæ with three apical spines; soldiers not nasute .... 23.

14. Rarely more than 15 mm in length; post-clypeus lighter colored than frons; fontanelle usually elongate and triangular. *Nasutiterme* .... 15.

Larger, usually more than 16 mm in length; post-clypeus little lighter than frons .... 18.

15. Eye large .... 16.

Eye small .... 17.

16. Head light red-brown; post-clypeus light yellow-brown; fontanelle short, nearly triangular; pronotum yellow; length 15.5 mm. *Nasutitermes panayensis* (Oshima).

Head brown; post-clypeus pale yellow, fontanelle conspicuous, white-yellow, Y-shaped, longer than ocellus; eye projecting; pronotum brown-yellow .... *Nasutitermes culasiensis* (Oshima).

Head brown; post-clypeus yellow-brown; fontanelle prominent, narrowly triangular; pronotum yellow-brown. *Nasutitermes chapmani* Light and Wilson.

Head dark mahogany-brown; post-clypeus yellow; fontanelle yellow-white, slitlike; antenna with 15 segments; pronotum yellow; length 15.4 mm .... *Nasutitermes luzonicus* (Oshima).

Head dark mahogany-brown; fontanelle small, inconspicuous; pronotum darker than in *luzonicus*. *Nasutitermes meridianus* Light and Wilson.

17. Head very dark black-brown; post-clypeus light brown; fontanelle broad, nearly twice as long as ocellus; antenna with 14 to 15 segments; pronotum rusty-brown; length 14.72 mm. *Nasutitermes mariveles* (Light and Wilson).

Head very dark brown; post-clypeus pale yellow-brown; fontanelle narrow, club-shaped; antenna with 13 segments; pronotum rusty-brown length 11 mm. *Nasutitermes mindanensis* Light and Wilson.

Head dark brown; post-clypeus pale brown; fontanelle white, conspicuous, narrowly lenticular, at least twice as long as ocellus; antenna with 16 segments; length 13 mm. *Nasutitermes taylori* Light and Wilson.

18. Third antennal segment slightly, if at all, longer than second .... 19.

Third antennal segment markedly longer than second .... 20.

19. Wings yellow-brown; head hairy; eyes very large and prominent; ocelli large, projecting; fontanelle small, narrow, distinct, white, pronotum with central notch in posterior margin. *Grallatotermes admirabilus* Light.

Wings black-brown; eyes medium in size; fontanelle long, three-cornered; medium in size; pronotum without notch in center. *Havilanditermes atripennis* (Haviland).

20. Third antennal segment twice as long as second; wing membrane unpigmented .... *Hospitalitermes* .... 21.

Third antennal segment about one and one half times as long as second; head weakly hairy; ocelli small, flat; fontanelle indistinct; wing membrane pigmented, brown .... *Lacessititermes* .... 22.

21. Head black-brown; pronotum without median emargination; length 17.5 mm .... *Hospitalitermes hospitalis* (Haviland).

Head brown-black; pronotum dark brown with median emargination; length 14.35 mm .... *Hospitalitermes luzonensis* (Oshima).

22. Pronotum with deeply notched posterior margin; fontanelle more than half as wide as ocellus. *Lacessititermes holmgreni* Light and Wilson.

Pronotum with entire posterior margin; fontanelle very narrow, slitlike .... *Lacessititermes palawanensis* (Light).

23. Head broad oval; first tooth of mandible much larger than second. *Capritermes paetensis* Oshima.

Head, dark brown, elongated, parallel-sided, first two teeth of mandible about equal .... *Microcerotermes* .... 24.

24. Head with sparse hairs; pronotum not emarginate posteriorly; length 8.5 to 9.5 mm .... *Microcerotermes distans* (Haviland).

Head hairy; pronotum weakly emarginate posteriorly, length 8.9 mm. *Microcerotermes los-banosensis* Oshima.

Key to known termites of the Philippines based on soldiers

No fontanelle; mandibles functional, used for biting, with marginal teeth, labrum not elongated; pronotum flat, broader than head. 1.

Fontanelle present; mandibles functional, used for biting, without marginal teeth; labrum not elongated; pronotum flat, narrower than head .... 5.

Fontanelle present; mandibles functional, used for biting, with marginal teeth; labrum greatly elongated with bilobed tip, pronotum flat, narrower than head; two types soldiers .... 8.

Fontanelle present; mandibles functional, used for biting with marginal teeth; pronotum saddle shaped .... 9.

Fontanelle present; length head with mandibles 4.2 mm, width 1.2 mm; mandibles asymmetrical, twisted, used for snapping; pronotum saddle-shaped .... *Capritermes paetensis* Oshima

Fontanelle present; mandibles degenerate and non-functional, head prolonged into a beak or nasus; pronotum saddle-shaped .... 12.

1. Front of head steeply sloping anteriorly, roundedly, but shallowly lobed; head short, length with mandibles 1.15 mm; light yellow-brown; antenna with 11 segments .... *Glyptotermes chapmani* Light.

Front of head roundedly, shallowly lobed; head more elongated, length with mandibles 2.6 mm, yellow-brown; antenna with 11 segments. *Glyptotermes magsaysayi* Snyder.

Front of head with deep V-shaped lobe; head elongated, length with mandibles 3.3 mm; brownish-yellow; antenna with 12 to 13 segments. *Glyptotermes franciæ* Snyder.

Front of head steeply sloping, deep anterior cavity, head short, black; antenna with 9 to 14 segments .... 2.

2. Head profile concave; not roughened anteriorly; mandibles short; antenna with 9 to 12 segments; pronotum not serrate anteriorly; length 3.25 mm .... *Cryptotermes cyanocephalus* Light.

Head profile not concave, roughened anteriorly; mandibles long, antenna with 13 to 14 segments; pronotum serrate anteriorly; length 5 to 6 mm .... *Cryptotermes dudleyi* Banks.

Front of head not steeply sloping or lobed; third segment antenna usually not modified; hind femora usually slender .... 3.

Front of head not steeply sloping or lobed; third segment antenna greatly modified; hind femora swollen .... 4.

3. Head yellow-to-red-brown, flattened, hairy; antenna with 15 segments, third larger than second or fourth, chitinized; length 9 to 11 mm. *Neotermes grandis* Light.

Head yellow, vaulted, narrowed anteriorly; antenna with 12 segments, third larger than second or fourth, length 8 mm. *Neotermes parviscutatus* Light.

Head red-brown, cylindrical, sides converging anteriorly, not hairy; antenna with 15 segments, second nearly as long as third; length 8 to 13 mm .... *Neotermes malatensis* (Oshima).

Head red-brown cylindrical, sides parallel, not hairy, antenna with 15 segments, 2nd shorter than 3rd; length 9 to 11 mm. *Neotermes lagunensis* (Oshima).

4. Head yellow to chestnut, with dense long and short hairs, short, thick; antenna with 15 to 17 segments; 3rd larger than 2nd or 4th; chitinized; gula broad in middle; length 7 to 9 mm. *Kalotermes mcgregori* Light.

Head red- to yellow-brown with coats of scattered hairs, long, rectangular; antenna with 13 to 14 segments, 3rd larger than 2nd, clavate, chitinized, gula slender in middle; length 4.5 to 5.0 mm. *Kalotermes taylori* Light.

5. Head elongated, parallel-sided; fontanelle in normal position, without tubular elongation, no groove forward; labrum pointed at tip; mandibles nearly straight .... *Heterotermes philippinensis* (Light).

Head broad-oval, narrowed anteriorly, fontanelle with groove running forward; labrum rounded at tip; mandibles bowed .... 6.

6. Head with mandibles 3.5 mm in length, head width 1.8 mm; antenna with 20 segments .... *Prorhinotermes tibiaoensis* (Oshima).

Head with mandibles 2.8 mm in length, head width 1.5 mm; antenna with 16 segments .... *Prorhinotermes gracilis* Light.

Head narrowed anteriorly; fontanelle opening at front with short tube; mandibles bowed .... 7.

7. Length of head with mandibles 2.75 mm, width of head 1.5 mm; antenna with 15 to 16 segments .... *Coptotermes flavicephalus* Oshima.

Length of head with mandibles 2.2 mm, width of head 1.2 mm; antenna with 14 to 15 segments .... *Coptotermes vastator* Light.

8. Large soldier, head yellow, sides rounded; fontanelle at front in channel to tip finely-haired, bilobed labrum; left mandible with two marginal teeth, right with one; antenna with 16 to 17 segments; length head with mandibles 1.98 mm, width 1.44. Small soldier, head yellow, slightly arched, suborbicular, shallow grooved from fontanelle to bilobed labrum; mandible teeth as in large soldier; antenna with 16 segments; length head with mandibles 1.33 mm, width 0.72 to 0.8 mm. *Schedorhinotermes longirostris* (Brauer).

Large soldier, head deeply yellow, suborbicular; tip labrum hyaline: antenna with 15 segments; length head with mandibles 1.81 to 2.00

mm, width 1.2 to 1.28 mm. Small soldier, antenna with 14 segments; length with mandibles 1.25 to 1.28, width 0.67 to 0.72 mm.

Schedorhinotermes tarakanensis (Oshima).

Large soldier, head dark yellow, quadrate; both mandibles with two marginal teeth; antenna with 16 segments; length of head with mandibles 3.0 mm, width 1.86 to 1.93 mm. Small soldier; head dark yellow, suborbicular, left mandible with two marginal teeth, right with one; antenna with 16 segments; length head with mandibles 1.87 mm, width 1.0 mm.

Schedorhinotermes bidentatus (Oshima).

9. Antenna with 17 segments; very large species; soldiers of two forms; 3rd segment antenna longer than 2nd; labrum with hyaline tips; left mandible with minute marginal teeth.

Macrotermes gilvus (Hagen).

Large species; soldiers of one form; 3rd segment antenna shorter than or as long as 2nd; labrum without hyaline apex; left mandible with marginal tooth .... 10.

Antenna with 13 segments; small species .... 11.

10. Length of head with mandibles 3.5 mm, width 2.0 mm.

Odontotermes (O.) dives (Hagen).

Length of head with mandibles 2.35 mm, width 1.4 mm.

Odontotermes (O.) paradenticulatus Ahmad.

11. Head yellow-brown, not twice as long as broad, head with mandibles 2.97 mm in length, 1.22 mm in width; mandibles minutely serrate .... *Microcerotermes philippinensis* Ahmad.

Head yellow-brown, not twice as long as broad, weakly arched, hairy, head with mandibles 2.77 mm in length, 1.14 mm in width, mandibles minutely serrate .... *Microcerotermes distans* (Haviland).

Head yellow, nearly twice as long as broad, head with mandibles 2.5 mm in length, 1.03 mm in width; mandibles very minutely serrate .... *Microcerotermes los-banosensis* Oshima.

12. Head not usually greatly produced, never strongly depressed, when produced, head narrow and constricted .... 13.

Head greatly produced behind and greatly depressed, dorsal profile strongly concave .... 14.

13 Antenna short, small species; if larger never with long antenna; head rarely constricted at middle; nasus conical; one soldier form .... *Nasutitermes* .... 15.

Antenna elongated, with 14 segments, 3rd segment longer than 2nd, shorter than 4th; head brownish-yellow, wider than long without nasus, not constricted at middle; nasus long, thick, conical; legs long; two soldier forms ...... *Havilanditermes atripennis* (Haviland).

14. Antenna elongated, with 13 segments, 3rd segment longer than 2nd or 4th; head black, nasus short and thick; legs moderately elongated, hind femora short of end of abdomen; one soldier form.

Grallatotermes .... 33.

Antenna elongated, with 14 segments, 3rd nearly twice as long as 2nd, shorter than 4th, 7th to 9th longest; head black, nasus long, thick at base; legs greatly elongated, hind femora longer than abdomen; one soldier form .... *Lacessititermes* .... 34.

Antenna greatly elongated, with 14 segments, 3rd three times as long as 2nd, longer than 4th; head black-brown, constricted; nasus short and slender; legs greatly elongated, hind femora longer than abdomen; one soldier form .... *Hospitalitermes* .... 35.

15. Head little produced behind, relatively short; usually without obvious constrictions behind antennæ .... 16.

Head much produced behind, relatively long, pyriform; with a constriction behind antennæ .... 29.

16. Nasus conical, at least twice as thick at base as at middle .... 17.

Nasus awl-shaped (cylindrical), less than twice as thick at base as at middle .... 25.

17. Head yellow .... *Nasutitermes culasiensis* (Oshima).

Head black, infuscated brown or clear brown .... 18.

18. Head black, dark brown, or brown with infuscation; tip of nasus typically red .... 19.

Head brown .... 22.

19. Very small, head with nasus less than 1.3 mm in length, head smoky yellow-brown, dorsal profile of head distinctly convex.
Nasutitermes mollis Light and Wilson.

Larger, head with nasus more than 1.35 mm in length, (usually much more); head profile flat or sinuous .... 20.

20. Tergites well chitinized, dark brown; nasus relatively short and thick, head-nasus index 0.44 to 0.65 .... 21.

Tergites weakly chitinized; pale yellowish-brown; head black, sharply contracted in front, variable; nasus longer; head-nasus index 0.53 to 0.57 mm .... *Nasutitermes luzonicus* (Oshima).

21. Antennal foveolæ not visible in dorsal view; head chestnut; nasus longer, more slender .... *Nasutitermes simulans* Light and Wilson.

Antenna foveolæ visible in dorsal view; head chestnut; nasus shorter and thicker .... *Nasutitermes latus* Light and Wilson.

22. Tergites dark brown, strongly pigmented; head brown.
Nasutitermes panayensis (Oshima).

Tergites pale to yellow .... 23.

23. Larger, head, antennæ, etc. orange-brown.
Nasutitermes meridianus Light and Wilson.

Smaller; head light (orange) brown; antennæ and tergites light .... 24.

24. Tergites very pale, nasus relatively narrow; from Luzon.
Nasutitermes oshimæ Light and Wilson.

Tergites yellow; nasus thick; from southern islands.
Nasutitermes chapmani Light and Wilson.

25. Very small head, with nasus less than 1.2 mm in length, gray smoky yellow-brown; mandible with vestigial point.
Nasutitermes parvus Light and Wilson.

Large head, with nasus more than 1.3 mm in length; mandible point long, spinelike and outwardly curved .... 26.

26. Larger; head with nasus more than 1.6 mm in length; head very broad; head index 1.05 mm or more, dull yellow; mandible point strongly outcurved .... *Nasutitermes rotundus* Light and Wilson.

Smaller; head, with nasus less than 1.55 mm in length; head narrower, head index not over 1.0; mandible point not strongly outcurved .... 27.

27. Anterolateral margins of head in dorsal view indented by slight but distinct constriction; head smoky yellow.
Nasutitermes balintauacensis (Oshima).

No such indentation .... 28.

28. Head dark smoky brown, particularly at base of nasus; tergites smoky brown; hump at base nasus very conspicuous.
Nasutitermes taylori (Light and Wilson).

Head light brown; tergites light yellow-brown; hump at base of nasus not conspicuous .... *Nasutitermes castaneus* (Oshima).

Head light smoky yellow; nasus dark (reddish) over entire length; tergites pale yellow; head convex in profile; hump at base nasus weak; mandible point lacking.
Nasutitermes mindanensis (Light and Wilson).

29. Nasus long; head pale brown; head-nasus index more than 0.7 mm.
Nasutitermes mcgregori (Oshima).

Nasus short, head-nasus index less than 0.5 mm .... 30.

30. Head smoky brown; nasus very dark at base; tergites dark, strongly chitinized; constriction very conspicuous.
Nasutitermes constricticeps (Light and Wilson).

Head orange to orange-brown; nasus not darkened, reddish; tergites pale yellow or light brown, not strongly chitinized; constriction not very conspicuous .... 31.

31. Constriction conspicuous; anteroventral corners of head capsule flaring; mandible with oblique sides, apical portion one-third as long as basal; point not long.
Nasutitermes busuangæ (Light and Wilson).

Constriction inconspicuous; anteroventral corners of head capsule not visible from above; mandible with nearly straight lateral side, apical portion nearly as long as basal, point long.
Nasutitermes brevicornis (Light and Wilson).

32. Head light smoky brown; nasus darker; tergites very pale yellow-brown, very slightly chitinized; constriction inconspicuous; mandible vestigial, with short point.
Nasutitermes mariveles (Light and Wilson).

33. Head concave in dorsal profile, slightly sinuous; length of head and nasus 1.8 mm .... *Grallatotermes admirabilus* Light.

Head less concave, not sinuous; length of head and nasus 1.95 mm
Grallatotermes splendidus Light and Wilson.

34. Head short, head-nasus index 0.7; apical portion of nasus red or yellowish .... *Lacessititermes holmgreni* Light and Wilson.

Head long, head-nasus index 0.5; apical portion of nasus not well marked .... *Lacessititermes palawanensis* Light.

35. **Very dark colored; antenna elongate; legs very long, length of head and nasus 1.87 mm** .... *Hospitalitermes hospitalis* (Haviland).
Dark; antenna, paler, less elongated; legs shorter; length of head and nasus 1.74 mm .... *Hospitalitermes luzonensis* (Oshima).

NOTES ON THE HABITS OF PHILIPPINE TERMITES

Family KALOTERMITIDÆ

Members of the family Kalotermitidæ are wood-dwelling in habit. They attack wood directly from the air, that is, they found and maintain their colonies inside the wood without any gallery connection to the soil. The majority of the Philippine species of this family can live in and feed on the moist heartwood and sapwood of living trees. A few species favor the relatively moist wood of abandoned logs and dead standing trees, and some species thrive best in apparently dry, sound wood.

Subfamily KALOTERMITINÆ

Kalotermes mcgregori Light and *K. taylori* Light are widely distributed in the Philippines. They are known to attack dry wood but have never been encountered in, or reported infesting, the woodwork of buildings. Records of their collection show that they attack dry stumps and logs of different tree species such as nangka (*Artocarpus heterophylla*), the dead heartwood and even the sapwood of living ipil-ipil (*Leucaena glauca*). The swarming period of the adults is not known.

Neotermes grandis Light, *N. lagunensis* (Oshima), *N. malatensis* (Oshima), *N. microphthalmus* Light, and *N. parviscutatus* Light attack living forest trees such as ipil-ipil (*Leucaena glauca*), cacawate (*Gliricidia sepium*), and rain tree (*Samanea saman*), as well as fruit trees, including avocado (*Persea americana*), cacao (*Theobroma cacao*), santol (*Sandoricum koetjape*), guava (*Psidium guajava*), and bitungol (*Flacourtia ramonchii*). Their infestations gain foothold in dead knots, limbs, exposed roots, and injuries on the trunks of trees, and often extend to the living sapwood and dead heartwood. Their galleries are often extensive and usually lined with moist, brownish excreta. The wood around their galleries is often stained. Records of their collection show that adults of some species of *Neotermes* were present in the months of April, May, and October.

Cryptotermes cyanocephalus Light and *C. dudleyi* Banks are dry-wood termites of great economic importance in the Philippines. Known locally as "unos," they infest the dry woodwork of buildings, furniture, lumber in storage, and other wood products. Their colonies, although usually small, are numerous and their galleries become so extensive as to render infested materials worthless and unfit for use. Their excrements are dry and pelletlike. Records of their collection show that the winged adults appear from April through October.

Glyptotermes chapmani Light, *G. franciæ* Snyder and *G. magsaysayi* Snyder infest abandoned logs, stumps, and dead standing trees. They seem to prefer wood with little moisture. Their galleries, which are usually lined with fecal material, are not extensive but may extend as a single or branched tunnel throughout the length of the infested log. Specimens of these termites were collected from white lauan (*Pentacme contorta*), pili (*Canarium ovatum*), rain tree (*Samanea saman*), and ilang ilang (*Cananga odorata*). Adults of *G. magsaysayi* are known to emerge in December, while those of *G. chapmani* may appear in May.

Family RHINOTERMITIDÆ

The termites of the family Rhinotermitidæ, except one genus (*Prorhinotermes*), are soil-dwelling. They build their main nest in the soil and feed upon wood in or on the ground. From such infested wood, they frequently extend their attack to wood not in contact with the ground by building covered runways or earthen tubes leading to the wood. Moisture is very essential to their existence.

Subfamily HETEROTERMITINÆ

Heterotermes philippinensis (Light) is known to attack the woodwork of buildings, especially in the Manila area. It was previously reported infesting the door jamb of a storeroom at the Philippine Normal School (now College) and the wooden porch of the Bureau of Science (now National Institute of Science and Technology) building. The record of its collection shows that winged adults were present in September.

Subfamily COPTOTERMITINÆ

Coptotermes flavicephalus Oshima and *C. vastator* Light are by far the most destructive of all Philippine subterranean termites. Of the two species, however, the latter is more widely distributed throughout the country, is more common and is frequently encountered in the woodwork of building. The attack on wood in contact with the ground is done by tunneling inside and throughout the length of the wood. Often, a secondary nest is built inside the wood. On wood not in contact with the ground, attack is made by crawling through cracks and crevices in concrete, or by building earthen tubes over other materials. When disturbed, the soldiers of both species secrete a milky fluid through their dorso-cephalic fontanelles. Winged adults appear in the months of May through October.

Subfamily RHINOTERMITINÆ

Prorhinotermes gracilis Light and *P. tibiaoensis* (Oshima) are frequently encountered in decayed heartwood of standing trees, especially in the hollows. Sometimes they are also found in rotten abandoned logs. Records of the collection of *P. tibiaoensis* show that this species is common in the hollow of bagtikan (*Parashorea plicata*) trees. An old report mentioned that *P. gracilis* was encountered in woodwork in a bathroom of a building, but present findings indicate that neither of these two species is economically important. The emergence of *P. tibiaoensis* adults is known to occur in November and December.

Schedorhinotermes bidentatus (Oshima), *S. longirostris* (Brauer), and *S. tarakanensis* (Oshima), build their nests in the soil and attack abandoned logs, dead stumps, bamboo, and rattan. They have never been reported infesting the woodwork of buildings. The flight period of the winged forms is not known.

Family TERMITIDÆ

This family of termites is subterranean in habit. The mandibles of its soldiers may be toothless (as in *Macrotermes*), minutely serrate (as in *Microcerotermes*), with a marginal tooth (as in *Odontotermes*), twisted (as in *Capritermes*); or vestigial (as in *Nasutitermes, Havilanditermes, Lacessititermes,* and *Hospitalitermes*). They feed on a variety of vegetable matter such as fungus, leaf molds, bark, decayed or weathered wood, and other organic detritus.

Subfamily AMITERMITINÆ

Microcerotermes distans (Haviland), *M. los banosensis* (Oshima), and *M. philippinensis* Ahmad attack dead stumps, abandoned logs, dead trees, waste lumber, and occasionally the woodwork of buildings. Their nests, as well as their slender, cylindrical runway tubes are semi-carton in nature. In Maco, Tagum, Davao, *M. los banosensis* was found attacking the structural member of a wooden wharf. In the forestry campus, College, Laguna, this species was found in the roof joists and rafters of a school building. A big semi-carton nest was located between two beams. Winged adults were found in the nest. Emergence of the winged adults known to occur from May to December.

Subfamily TERMITINÆ

Capritermes paetensis Oshima, the snapping (jumping) Philippine termite, thrives in moist decaying logs, stumps, and other rotting vegetable matter in the forest. The flight period of the winged adults is not known.

Subfamily MACROTERMITINÆ

Macrotermes gilvus (Hagen) is the common mound-building termite. Inside its mound are spongelike structures wherein a species of fungus is grown for its food. Although this termite feeds principally on fungus, it occasionally attacks abandoned logs, fence posts, stakes, lumber on the ground, and even the woodwork of buildings. It also frequently builds broad earthen tubes on the trunks of trees to feed on the outer dead layer of bark. The emergence of the winged adults of this species takes place during the rainy season, from May to September.

Odontotermes (*O.*) *dives* (Hagen) and *O.* (*O.*) *paradenticulatus* Ahmad are similar in habits to *Macrotermes gilvus* except that they do not construct mounds. They also feed on decayed bamboo and rattan in the forest. Their earthen tubes on the trunks of trees are broad and extensive, covering a wide area of the trunk's surface. The flight period of the adults is not known.

Subfamily NASUTITERMITINÆ

The group of termites belonging to this subfamily have soldiers that are nasutes, that is, their heads are drawn out into a rostrum or noselike projection.

The genus *Nasutitermes* consists of twenty widely distributed species in the Philippines. They construct semi-carton runways or tubes and nests which are often located on the trunks of trees. They attack abandoned logs, dead stumps and branches of trees, coconut trunks, old posts, discarded lumber, and other wooden wastes in the forest. They occasionally climb buildings but have never been observed doing severe damage. Emergence of the winged adults of some species occurs from May to October.

Havilanditermes atripennis (Haviland) is found in Borneo, Sumatra, and in the Philippines (Cotabato, Mt. Maquiling, Laguna, and Tablas). It lives under the bark of living trees, in rotting wood, and under rotten logs. It builds earthen runways. The emergence period of the adults is not known.

Grallatotermes admirabilus Light is a dark, long-legged, and heavily chitinized species which is known to occur in Panay and Negros. Adults of this species were collected in the months of April and May. It is believed that this species forages in the open. Another species, *G. splendidus* Light, which is weakly chitinized, is known to occur in the swampy jungle on the shore of Lake Casili, Arayat, Pampanga. The emergence period of the adults is not known.

These two species build carton nests and have no covered runways.

Lacessititermes palawanensis Light was first found at an elevation of 4,500 feet at Thumb Peak, Iwahig, Palawan. It is known to build small, very light paper nests in small shrubs or rattan with no covered runway above or below the nest. Records of its collection show that adults were present in November. Another species, *L. holmgreni* Light and Wilson is found in Dinagat Island, Surigao. It builds carton nests. The winged adults of this species are known to appear in May and June.

Hospitalitermes hospitalis (Haviland) occurs in Borneo, Malay Peninsula, Sumatra, and the Philippines (San Francisco del Monte, Manila). Another species, *H. luzonensis* (Oshima) is very common in College, Laguna. These two species are dark, long-legged, and heavily chitinized. They are foraging species, travelling long distances in columns in the open. They feed on fragments of decayed leaves, fungus, and other waste vegetable matter. They build black, oily, semi-carton nests at the base or in the hollows of trees. They occasionally climb buildings and build their nests between walls in bathrooms. Winged adults have been reported to appear in May to October.

APPENDIX

Abdomen: the end portion of the insect body connected to the head by the thorax which bears the wings and legs.

Antenna (antennæ): two sensory organs (with bead or rodlike joints) borne one on each side of the head, commonly called "feelers."

Antennal foveole: the pits from which the antennæ arise.

Castaneous: chestnut color.

Cavate: hollowed out.

Chitinized: horny, usually colored.

Ciliate: fringed with rows of parallel hairs.

Compound eye: the seeing organ of insects composed of many facets or lenslike divisions.

Costa: the thickened front margin or vein of the wing.

Cubitus: the vein below the middle vein.

Dentate: with minute teeth or serrate.

Emarginate: notched or with rounded or angular section cut from the margin.

Femur: (femora): the thigh, usually the stoutest section of the leg.

Fontanelle: the frontal gland or pore on the top of the head of termites, centered between the eyes.

Frons: front of head from fontanelle to post-clypeus.

Gula: the rodlike plate in the center of the head beneath.

Head index: head width divided by head length without nasus.

Head nasus index: nasus length divided by head length without nasus.

Infuscated: darkened with a brownish tinge.

Labrum: the upper lip which covers the base of the mandibles.

Mandible: the lateral upper jaw of biting insects.

Median vein: the second vein from the rim of costa.

Nasus: Rostrum, beak or noselike frontal process.

Nasute: soldier with nasus.

Ocellus (ocelli): the simple eye or a single convex or beadlike lens, one on each side of the head near the compound eye.

Post-clypeus: the segment between the labrum and front of the head.

Pronotum: the front or first segment of the thorax.

Punctate: set with impressed points or punctures.

Pyriform: pear-shaped.

Reticulate: like network.

Serrate: with minute teeth, dentate.

Subcostal vein: the vein below the rim of the wing.

Tarsus (tarsi): the foot, the distal part of the leg.

Tergite (tergites): the dorsal surface of the segments of the abdomen.

Thorax: the second segment bearing the three pairs of legs of the insect between the head and abdomen. It consists of the prothorax, meso- and metathorax, which two latter portions bear the wings.

Tibia (tibiæ): the segment of the leg between the thigh and the foot.

Wing scale: the base of the wing left attached to the thorax, separated from the main wing by a line of weakness where the wing breaks off after flight.

LITTORAL HOLOTHURIOIDEA OF HUNDRED ISLANDS AND VICINITY, LINGAYEN GULF, LUZON ISLAND, PHILIPPINES

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TWENTY-FOUR TEXT FIGURES

The writer surveyed for the third time in the summer of 1953 the marine fauna of the Hundred Islands and vicinity in the Gulf of Lingayen. In view of the extensive areas and the distances between the different collecting grounds covered as well as the deep channels that separate the different groups of islands, it was not possible to make a thorough collection especially considering the limited facilities available in the survey. This paper, therefore, does not contain a complete list of the possible species expected to be encountered in the holothurian fauna of the great waters of Lingayen Gulf.

The invertebrate animals collected represent only a very insignificant segment of the fauna of the locality. For instance the shallow waters have not been fully explored while the deeper habitats remained practically untouched. It is hoped that the project to make Lucap Bay and the waters around the Hundred Islands, a branch of the marine biological station of the University of the Philippines may be realized. This would undoubtedly bring to light a much extensive knowledge of the biological fauna and flora of these very interesting but practically still unknown waters of the Philippines.

The area covered in the present study is quite limited. It comprise only that in the neighborhood of the Shell, Virgin, Devil's Kitchen, Quezon, Quirino, and Murphy Islands. Only the small areas of shallow coral reefs were investigated partially. Outside the Hundred Islands group, the Lucap Bay, Telbang Bay, Panakalan and Tandoyong Islet's vicinities were the only areas included in this partial survey. Limited as the extent of this study has been, yet, the results apparently indicate very encouraging trend. One, therefore, can expect to get very satisfactory results with an expedition of bigger staff provided with more complete facilities for research.

The writer's original plan was to report on the "Marine Fauna of the Hundred Islands and Vicinity." However, because of the lack of time to study and describe the different species of invertebrates collected, the present paper is limited only to the "Littoral Holothurioidea of Hundred Islands and Vicinity." It is hoped to be able to report on the other groups of the invertebrate fauna in the near future.

SUMMARY LIST OF THE HOLOTHURIOIDEA COLLECTED FROM HUNDRED ISLANDS AND VICINITY

Order ASPIDOCHIROTA Grube

Family HOLOTHURIIDÆ Ludwig

Subfamily HOLOTHURIINÆ Ludwig

Genus HOLOTHURIA Linnæus, 1758

1. *Holothuria atra* Jaeger
2. *H. pulla* selenka
3. *H. graeffei* Semper
4. *H. argus* (Jaeger)
5. *H. vitiensis* Semper
6. *H. scabra* Jaeger
7. *H. edulis* Lesson
8. *H. marmorata* Jaeger
9. *H. impatiens* (Forskål)
10. *H. fuscocinerea* Jaeger
11. *H. fuscocinerea* var. *pervicax* Bedford
12. *H. bivittata* Mitsukuri

Genus ACTINOPYGA Bronn

13. *Actinopyga lecanora* (Jaeger)
14. *A. echinites* (Jaeger)
15. *A. mauritiana* (Quoy & Gaimard)
16. *A. miliaris* (Quoy & Gaimard)
17. *A. lecanora* (Jaeger)

Genus ARGIODIA Pearson, 1913

18. *Argiodia maculata* (Brandt)

Family STICHOPIDÆ Brandt, 1835

Genus STICHOPUS Brandt, 1835

19. *Stichopus chloronotus* Brandt
20. *S. variegatus* Semper
21. *S. variegatus* var. *Hermanni* Semper
22. *S. horrens* Selenka

Order DENDROCHIROTA

Family PHYLLOPHORIDÆ

Genus THYONE Oken, 1815

23. *Thyone buccalis lourdesæ* subsp. nov.

Order APODA Brandt, 1835

Family SYNAPTIDÆ Ostergren, 1905

Genus SYNAPTA Eschscholtz, 1829

24. *Synapta maculata* (Chamisso & Eysenhardt)

Genus OPHEODESOMA Fisher, 1907

25. *Opheodesoma grisea* (Semper)

Key to the species of Holothuria

A. Tentacles 20:

B. No tables among calcareous deposits:

C. Calcareous spicules more or less incomplete rosettes:

Dorsal side with large brown elliptical or circular spots encircled with white .... *argus*

No conspicuous spots, though irregular dark blotches may occur. *marmorata*

Hemogenous dark orange-brown dorsally and lighter ventrally with numerous tiny dark spots (tips of contracted pedicels). *vitiensis.*

Dorsal side purplish brown intermixed with numerous irregular ramifying blotches of light brown giving a semi-variegated appearance .... *bivittata*

CC. Calcareous spicules rosettes and trident-shaped tower with 3 basal rods and 1 uppermost spinous rod with few knobbed rods; Somewhat variegated purplish coloration or violet brown with slight shades of orange and numerous tiny dark spots scattered over body and with prominent stout 25 to 27 tentacles darker than body because of their black stalks .... *graeffei*

BB. Tables among calcareous deposits:

D. Tables accompanied by accessory particles:

E. Accessory particles small irregular plates, usually perforated:

Pedicles and papillæ well developed, numerous both dorsally and ventrally; black unicolor without Cuvierian organs; disk of tables fairly well developed; accessory particles rosettes and some appearing as small plates with 4 perforations or slits. *atra*

EE. Accessory particles buttons or flat perforated plates:

F. Buttons, at least in large part, with knobs or rough surface:

G. Tables regular, spire low, made up of 4 rods and only 1 or 2 crossbars .... *scabra*

FF. Buttons smooth, often reduced, with only 2 to 4 holes:

H. Papillæ all over body, situated upon conical eminences giving a characteristic papillated appearance. *impatiens*

Papillæ all over body but not situated upon conical eminences; thinner body wall and with Cuvierian organs; coloration black; accessory particles irregular buttons, mostly assymetrical .... *pulla*

Pedicels and papillæ small, not very numerous; upper side brown, lower side rose red in life, dirty white in preserved state; disk of tables reduced to ring; accessory particles in the form of regular and irregular buttons, the latter asymmetrical .... *edulis*

Pedicels and papillæ somewhat arranged in indistinct rows over body; upper side greenish brown with tips of papillæ very conspicuous appearing like dark spots; dark transverse bands may be conspicuous in life; simple tables and imperfect buttons .... *fuscocinerea*

With buttons of two types, regular and irregular:

The regular ones with from 3 to 4 pairs of holes and smooth margin, the irregular ones with incomplete holes and broken undulating margins.

fuscocinerea var. *pervicax*

HOLOTHURIA ATRA Jaeger. **Fig. 1a–c.**

Holodeima atra PANNING (1944) 9, 10, 12.

Holothuria radackensis CHAMISSO & EYSENHARDT (1821) 352, *pl. 28.*

H. amboinensis SEMPER (1868) 92, 279.

H. atra Jaeger var. *amboinensis* THEEL (1886a) 214; Bedford (1898) 839, (1899) 147.

H. sanguinolenta BELL (1893); DOMANTAY (1933) 73, *pl. 3, fig. 3.*

H. atra JAEGER (1833) 22; SELENKA (1867) 327, *pl. 18, 52–53,* (1868) 250; SEMPER (1868) 88, 250, 278, *pl. 26,* (1869) 120; LUDWIG (1881) 596, (1882) 137, (1883) 170, (1887b) 32, (1887d) 1217, (1887c) 1244, (1889) 559; BELL (1884) 510, (1886) 28, (1887a) 140, (1887c) 654, 657, (1888) 389; LAMPERT (1885) 84, (1896) 55; THEEL (1886a) 181, 213, *pl. 7, fig. 4;* SLUITER (1887) 188, (1894) 103, (1889–92) 329, *pl. 3, fig. 30, pl. 6, fig. 5,* (1895) 78; SAVILLE-KENT (1893) 49, 55, 102, 121, 234, 238, *pl. 33b;* STUDER (1893) 191, 234; KOEHLER (1895a) 382; WHITELEGGE (1897) 161; (1903) 8, 13; HADLEY (1899) 530; H. L. CLARK (1901a) 495, (1902b) 530, (1920) 148, (1921) 174, (1923) 421, (1925) 102, (1932) 231, (1946) 427; VOLTSKOW (1902) 565; KONINGSBERGER (1904) 47, *pl. 8, fig. 2;* CARDINER (1904) 339; EDWARD (1905) 383, (1908a) 537–540, (1908b) 236–301, *pls. 1–5;* HERDMAN (1906) 447; FISHER (1907) 657, *pl. 70, fig. 2;* KOEHLER & VANEY (1908) 5, (1910) 101; PEARSON (1910a) 176, (1913) 67, *pl. 9, fig. 11;* MITSUKURI (1912) 64, *text fig. 14;* ERWE (1913) 374, *pl. 6, fig. 14;* BROOKE (1927) 164; PANNING (1928a) 221, (1935) 30, *text-fig. 22;* T. A. STEPHENSON, et al. (1931) 45, 50, 55; BAKER (1929a) 141–143, (1928b) 167–171; ENGEL (1933) 4, *pl. 1, fig. 1, text fig. 1–6;* DOMANTAY (1933a) 135, 140, (1953b) 110–112, (1954a) 337, 339–340, (1954b) 325–330, (1957) 32.

Ludwigothuria atra DEICHMANN (1958) 312, *pl. 2, fig. 18–23.*

This species has been reported by the writer in 1933 from Puerto Galera, Mindoro under *Holothuria sanguinolenta.* Its color is black in life as well as in its preserved state unlike *Holothuria pulla* to which it is usually confused which fades to brown when preserved. *H. atra* has no Cuvierian organs unlike *H. pulla* which has them. When handled alive and pressed hard, a purplish violet color may be noticed adhering to the hand. Average size for adult is 200 to 300 mm. It is a widespread species ranging from Mozambique to Tahiti and northward to tropical Japan. Use for commerce as beche-de-mer, under the name of "balat" or "balatan."

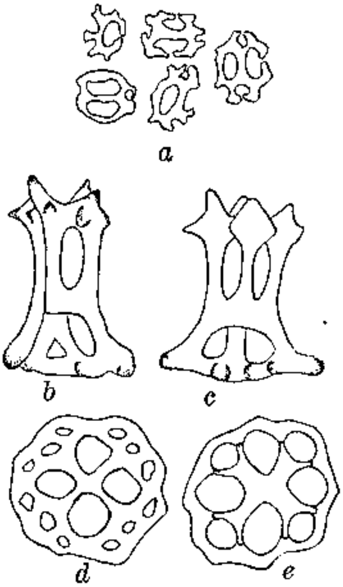

FIG. 1. *Holothuria atra* Jaeger: *a*, various rosettes from body wall, average actual length 0.03 mm; *b–c*, side view of tables from body wall, average actual height 0.04 mm; *d*, bottom view of a table from body wall, average actual diameter of disk 0.04 mm; *e*, top view of a table from body wall.

HOLOTHURIA PULLA Salenka. Fig. 2a-h.

Halodeima pulla PANNING (1944) 9; URETA & DOMANTAY (1956). Dissertation manuscript.

Microthele aethiops BRANDT (1835) 55.

Holothuria aethiops SELENKA (1867) 331; SEMPER (1868) 90, 250; LUDWIG (1881) 597; LAMPERT (1885) 84; THEEL (1886a) 214.

Holothuria atra DOMANTAY (1933) 61–62, *pl. 2, fig. 6.*

Holothuria pulla SELENKA (1867) 326, *pl. 18, fig. 51;* SEMPER (1868) 92, 279; BELL (1884c) 510; THEEL (1886a) 214; PEARSON (1913) 69; PANNING (1934) 34; DOMANTAY (1953a) 135, (1953b) 110, 116–117, (1954a) 337, 347–348, (1957) 32.

This species has been reported by the same writer in 1933 from Puerto Galera, Mindoro under *Holothuria atra.* The two species are usually confused with each other because of their resemblance in life when both are relaxed with their tentacles extended. Both black in life but *H. pulla* has a thinner body wall and softer in texture with Cuvierian organs. Pedicels and papillæ more conspicuous than in *H. atra.* It does not give purplish violet color when pressed hard to the hand. In preserved state it fades easily to brown or even much paler to almost white when preserved for a long time. Not used for commerce and not edible.

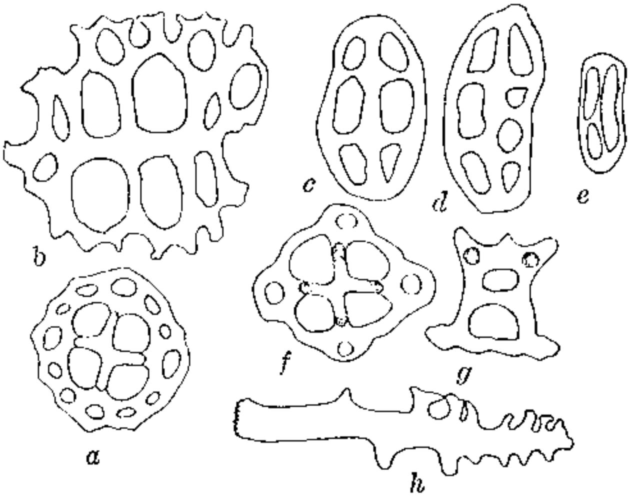

Fig. 2. *Holothuria pulla* Selenka: *a*, bottom view of a table from body wall, average actual diameter of disk 0.05 mm; *b*, large supporting plate from tube foot; *c–d*, buttons from body wall; average actual length 0.06 mm; *e*, irregular small button from body wall; *f*, top view of a table from body wall; *g*, side view of a table from body wall; *h*, a portion of supporting rod from tube foot.

HOLOTHURIA ARGUS Jaeger. **Fig. 3a-g.**

Bohadschia argus Jaeger (1833) 19, *pl. 2, fig. 1;* Selenka (1867) 320; Bell (1886) 27; Pearson (1914a) 170; Panning (1944) 8, 10, 12, 36, *text figs. 7, 8.*

Holothuria leopardus Saville-Kent (1890) *pl. 1, fig. 2.*

Holothuria argus Semper (1868) 80, 277, *pl. 30, fig. 11;* Ludwig (1882) 135, (1883) 168, (1889–92) 329; Lampert (1885) 87, (1889) 808; Theel (1886a) 203; Bell (1887c) 653, (1888) 389; Saville-Kent (1893) 56, 237, *pl. 34, fig. 2,* colored *pl. 12, fig. 7;* Studer (1893) 234, 248; Koehler (1895c) 279; Whitelegge (1897) 161; Sluiter (1901) 12; Koningsberger (1904) 45; Mitsukuri (1912) 60, *pl. 3, fig. 30, text fig. 13;* Pearson (1913) 56, *pl. 7, fig. 5;* H. L. Clark (1921) 174, (1946) 425; Panning (1929) 121, *text fig. 2;* Domantay (1933) 60, *pl. 1, fig. 2,* (1953a) 135, (1953b) 110–111, (1954a) 337–339, (1957) 32.

It is one of common species found almost every where in the Philippine waters. It has a wide range in Indo-Pacific region. It grows to a length of a foot or more, quite plump with thick Cuvierian organs. In life ground color is brown, dull gray, or purplish of some shades, with conspicuous white encircled spots of a different and contrasting shade of brown which does not fade at all in preserved state. It is used for commerce but of the poor grade of beche-de-mer.

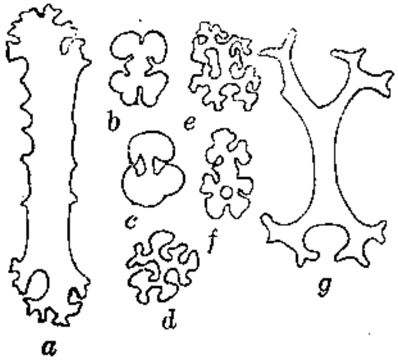

FIG. 3. *Holothuria argus* (Jaeger): *a–g*, supporting rods from tube foot, average actual length 0.11 mm; *b–f*, various rosettes from body wall average actual length 0.018 mm.

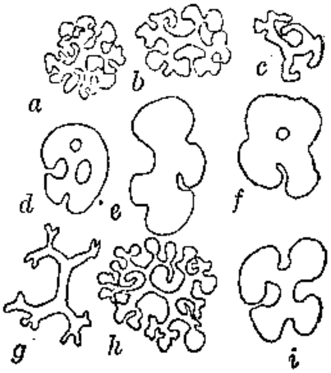

FIG. 4. *Holothuria vitiensis* Semper: *a–i*, various forms of rosettes from body wall. Average actual length 0.02 mm.

HOLOTHURIA VITIENSIS Semper. Fig. 4a-i.

Bohadschia vitiensis Pearson (1914a) 170.

Holothuria tenuissima Semper (1868) 85, 248, 277, *pl. 30, fig. 20;* Lampert (1885) 88; Ludwig (1882) 136; Theel (1886a) 204; Sluiter (1887) 185, (1901) 14; Koehler (1895a) 383; Pearson (1903) 201; Koehler & Vaney (1908) 16.

Holothuria clemens Ludwig (1875) 31, *pl. 7, fig. 49;* Lampert (1885) 88; Theel (1886a) 204; Mitsukuri (1912) 149.

Holothuria similis Semper (1886) 85, 277, *pls. 25 & 30, fig. 18;* Lampert (1885) 88; Theel (1886a) 204.

Holothuria kollikeri Semper (1868) 86, 277, *pls. 30, fig. 25, pl. 35, fig. 7;* Lampert (1885) 87; Theel (1886a) 204; Ludwig (1887c) 31; Ludwig & Barthels. (1892) 632.

Bohadschia marmorata viticnsis Panning (1944) 10, 40–41, *text-fig. 11.*

Holothuria (Bohadschia) vitiensis Panning (1929) 122, *text fig. 3.*

Holothuria vitiensis Semper (1868) 80, 247, 277, *pl. 30, fig. 12;* Lampert (1885) 89; Theel (1886a); Ludwig (1889–92) 330; Saville-Kent (1893) 238; Slutter (1895) 78, (1901) 13; Koehler (1895a) 382; Pearson (1903) 201, (1903) 57, *pl. 7, fig. 6;* Koningsberger (1904) 45; Fisher (1907) 653; Mitsukuri (1912) 146; Domantay (1933) 76–77, *pl. 1, fig. 2,* (1953a) 135, (1953b) 110, 119–120, (1957) 32.

It is also one of the common species widely found in Philippine waters. It grows large to over a foot long; plump, with plenty of Cuvierian organs. Body wall hardy but not apparently desired for commerce. Color in life as well as in dried or preserved state is dark orange dorsally and much lighter ventrally, dotted with numerous tiny darker spots representing the tips of retracted pedicels.

HOLOTHURIA SCABRA Jaeger. Fig. 5a-d.

Holothuria tigris SELENKA (1867) 333, *pl. 19, figs. 70–72.*
Holothuria cadelli BELL (1887) 144, *pl. 16, fig. 7.*
Holothuria gallensis PEARSON (1903) 203, *pl. 3, figs. 46–50.*
Holothuria scabra JAEGER (1833) 23; SELENKA (1867) 341, (1868) 118; SEMPER (1868) 79, 247, 277; LUDWIG (1880) 6, (1881) 559, (1882) 135, (1883) 168, (1887d) 1224, (1887e) 1242, (1888) 807, (1889–92) 330, (1899) 557; HAACKE (1880) 46; LAMPERT (1885) 69; (1896) 54; THEEL (1886a) 234; SLUITER (1887) 193, (1894) 103, (1895) 78, (1901) 11; KONINGSBERGER (1904) 52; KOEHLER & VANEY (1908) 16; PEARSON (1910a) 180, (1910b) 193, (1913) 87, *pl. 13, fig. 22;* MITSUKURI (1912) 135, *text fig. 24; H. L.* CLARK (1920) 150, (1921) 181, (1923) 424, (1932) 235, (1946) 430; SCHMIDT (1930) 415; DOMANTAY (1933) 74–76, *pl. 2, fig. 3,* (1953a) 135, (1953b) 117–118, (1957) 32; PANNING (1941) 13–16, *text fig. 9, 10,* (1944) 10, 13.

Very common in all Philippine waters and a typical Indo-Pacific species, ranging from Port Natal to Red Sea on East African coast and eastward to Caroline and Fiji islands, northward to Ryukyu Islands, and southward to Lord Howe Island. Reported from Barrier Reef region and in Torres Strait. With hardy body wall without Cuvierian organs. Grows to around 400 mm long by about one-fourth as much in diameter. Color unusually varied, upper surface ranges from light grayish green or dull cream color to dark greenish olive brown, some with transverse black bands and finely speckled. Ventral side whitish. Pedicels and papillæ usually with dark tips. Extensively used for beche-de-mer and eaten fresh.

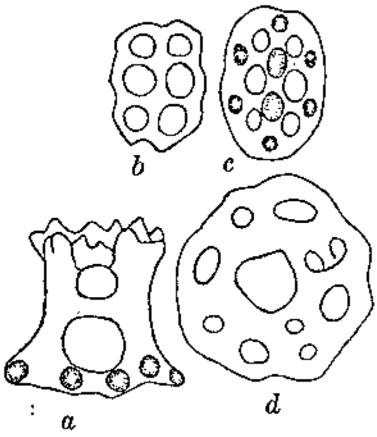

FIG. 5. *Holothuria scabra* Jaeger: *a*, side view of a table from body wall, average actual height 0.066 mm; *b*, button-like supporting plate from tube foot, average acutal length 0.12 mm; *c*, knobbed button from body wall, average actual length 0.05 mm; *d*, bottom view of a table from body wall, average actual diameter of disk 0.09 mm.

HOLOTHURIA EDULIS Lesson. **Fig. 6a–c.**

Halodeima edulis Panning (1944) 9, 10, 13.
Trepang edulis Jaeger (1833); Brandt (1835).
Holothuria fusco-cinerea Selenka (1867).
Holothuria signata Ludwig (1875); Lampert (1885), (1895); Théel (1886).
Holothuria albida Bell (1887).
Holothuria edulis Lesson (1830); Semper (1868); Ludwig (1882), (1887), (1888), (1889); Lampert (1885); Theel (1886); Sluiter (1901); Koehler (1896); Bedford (1889); Koningsberger (1904); Pearson (1913–14); H. L. Clark (1921), (1946) 427; Domantay (1933) 63–64, *pl. 1, fig. 11,* (1953a) 135, (1954a) 337, 342–43, (1957) 32.

Common species in Philippine waters; found from Aden and Mozambique to Philippines and Ryukyus on North and to Caroline and Fiji islands on East. Reported in Australia from eastern coast between Murray Islands and the Capricorn group. Medium-sized species less than 300 mm long. Color distinct and handsome, brownish dorsally and rose red ventrally. In preserved state rose red turns white. No Cuvierian organs. Used for beche-de-mer and as food in fresh condition.

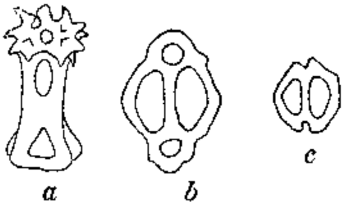

Fig. 6. *Holothuria edulis* Lesson: *a*, side view of a table from body wall, average actual height 0.06 mm; *b–c*, large and small buttons from body wall, average actual length 0.03 mm.

HOLOTHURIA MARMORATA (Jaeger). **Fig. 7a–c.**

Bohadschia marmorata Jaeger (1833) 18, *pl. 3, fig. 9–10;* Selenka (1867) 339; Pearson (1914a) 170.
Bohadschia marmorata marmorata Panning (1944) 10, 12, 39–40, *text figs. 9, 10.*
Sporadipus (Colpochirota) ualensis Brandt (1835) 146.
Holothuria Brandt Selenka (1867) 320.
Holothuria utrimoquestigmosa Haacke (1880) 48.
Holothuria (Bohadschia) marmorata Panning (1929) 120–121, *text fig. 1.*
Holothuria marmorata Selenka (1868) 118; Semper (1868) 79, 227, *pl. 30, fig. 10, pl. 35, fig. 3, pl. 36, fig. 8, pl. 37, figs. 1–4;* Ludwig (1881) 594, (1882) 135, (1883) 186, (1888) 806, (1889–92) 330, (1894) 7; Ludwig & Barthels (1892) 632; Lampert (1885) 86; Theel (1886a) 202; Sluiter (1887) 185, (1894) 103, (1895) 78, (1901) 12; Bell (1887c) 145, (1888) 382; Saville-Kent (1893) 236; Mitsukuri (1896) 406, (1912) 106, fig. *21;*

Pearson (1903) 202, (1910) 179, (1913) 54, *pl. 7, fig. 4;* Koningsberger (1904); H. L. Clark (1921) 180, (1946) 426; Domantay (1953b) 110, 115, (1957) 32.

One of most common species encountered around Panakalan Islet in Lingayen Gulf as well as throughout Philippine waters. Its distribution ranges from Mauritius to Fiji and north to Ryukyus. It grows to 400 mm long more or less, with a diameter about one-fourth as much. Color in life pale or yellow brown above, usually with 2 or 3 large irregular brown blotches, and lighter to almost white ventrally. Pedicels darker than body wall, and tentacles gray-brown, darker than body too. Color chestnut-brown speckled with numerous tiny spots dorsally and lighter in color ventrally with brownish violet blotches dotted with purplish spots. Used for beche-de-mer and also eaten fresh.

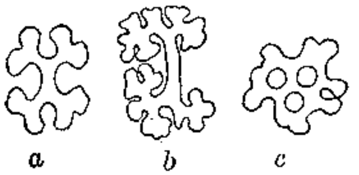

Fig. 7. *Holothuria marmorata* Jaeger: *a–c*, various forms of rosettes from body wall.

HOLOTHURIA IMPATIENS (Forskål). Fig. 8a-f.

Fistularia impatiens Forskål (1776) 121–129, *pl. 39, fig. B.*

Holothuria aphanes Lampert (1885) 242; Ostergren (1898) 233; Sluiter (1901) 16.

Holothuria fulva Qouy & Gaimard (1833) 135.

Holothuria botellus Selenka (1867) 335, *pl. 19, figs. 82–84,* (1888) 117; Semper (1868) 82, 248; Savile-Kent (1893) 234, 238.

Holothuria impatiens Selenka (1867) 340; Semper (1868) 82, 277, (1869) 120; Gray (1872) 123; V. Marenzeller (1874) 320; Ludwig (1879) 569, (1880) 6, (1882) 126, (1883) 169, (1887c) 31, (1887d) 1226, (1888) 806, (1889–92) 329, (1899) 558; Haacke (1880) 46; Bell (1894c) 510, (1887a) 510, (1887b) 140, (1887c) 654, (1888) 389; Lampert (1885) 65, (1889) 812, (1896) 54, (1889) 312; Theel (1896) 7; Sluiter (1887) 47, (1895) 78, (1901) 9; Herourd (1889) 677, (1893) 134; Saville-Kent (1893) 233–237; Koehler (1895b) 282, (1895c) 12, *fig. 11,* (1921) 173, *fig. 129,* (1927) 214, *pl. 16, fig. 19;* Bordas (1898) 840, (1889a) 187–204, (1899) 16, *pl. 1;* Bedford (1898) 840, (1899) 145; Ostergren (1898) 233–237; Risso (1899) 133–141, (1900) 38–41; H. L. Clark (1902a) 258, (1902b) 528, (1920) 149, (1921) 178, *fig. 2,* (1923) 423, (1925) 103, (1926) 192, (1932) 232, (1938) 521, (1946) 434; Koningsberger (1904) 51, *pl. 8, fig. 3;* Fisher (1907) 660, *pl. 69, fig. 4;* Koehler & Vaney (1908) 8; Pearson (1910a) 178, (1910b) 192, (1913) 85, *pl. 13, fig. 21,* (1914) 171; Mitsukuri (1912) 80, *text fig. 17;* Erwe (1913) 369; Mortensen (1926) 117, Deichmann (1926) *fig. 11,* (1930) 64, *pl. 3, fig. 17–18;* Schmidt (1929) 1365, 1391, *figs. 197–198;* (1930) 406–412, 419–423, 459, 483, *figs. 36–43, 52, 53, 64, 75, 85, 98;* T. A. Stephenson, et al. (1931) 55; DOMANTAY (1933) 66–67, *pl, 2, fig. 4*, (1935a) 135, (1953b) 110, 114–115, (1954a) 237, 344-346, (1957) 32; PANNING (1935) 86–88, *text fig. 72*, (1944) 13.

Brandtothuria impatiens (Forskål) DEICHMANN, E. (1958) 293–*294, pl. 1, figs. 14–15.*

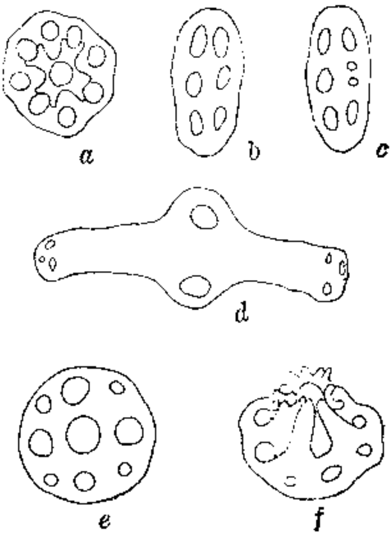

FIG. 8. *Holothuria impatiens* (Forskål): *a*, top view of a table from body wall; *b–c*, buttons from body wall, average actual length 0.11 mm and width 0.05 mm; *d*, supporting rod from tube foot, average actual length 0.25 mm; *c*, bottom view of table from body wall, average actual diameter of disk 0.13 mm; f, side view of a table from body wall, average actual height 0.074 mm.

Medium-sized species usually found sheltered in coral rocks. Slender and cylindrical in form. Pedicels scattered all over body and distinctly papillated, conical tips with warty bases. Color more or less variegated, often transversely banded on dorsal side. Ground color gray or brown, with black, white and dull purple shades and markings. Body wall hardy. Anal and oral openings terminal; without Cuvierian organs. Edible and usually eaten fresh. Large specimen 400 mm long and 45 mm diameter has been reported by Semper 1868 but his size has never been encountered by the writer. It has a tropicopolitan or circumstropical distribution. It ranges from Mediterranean and Mozambique across Indian Ocean and Pacific to Hawaii, Galapagos and Panamic region, and also occurs throughout West Indian area from Bermuda to Trinidad. It has been also reported from Tropical coast to Australia from Queensland to Shark Bay on western coast.

HOLOTHURIA FUSCOCINEREA Jaeger. Fig. 9a-l.

Holothuria curiosa LUDWIG (1875) 34, *pl. 7, fig. 29*, LAMPERT (1885) 64; THEEL (1886a) 181, 220, *pl. 8, fig. 9;* SLUITER (1901) 10; PEARSON (1910a) 177, (1913) 75–76; DOMANTAY (1953a) 135, (1953b) 113–114.

Holothuria (Holothria) curiosa PANNING (1935) 4–5, *text fig. 107.*

Holothuria pervicax SELENKA (1867); LUDWIG (1897); SLUITER (1901); FISHER (1907); H. L. CLARK (1921).

Holothuria depressa LUDWIG (1875); LAMPERT (1895).
Holothuria mammiculata HAACKE (1880).
Holothuria dofleinii AUGUSTIN (1908); PEARSON (1910).
Holothuria fusco-cinerea JAEGER (1838); SEMPER (1868) 88, *pl. 27, 30, fig. 22;* LUDWIG (1882) 137, (1887d) 1227; THEEL (1886a) 221; LUDWIG & BATHELS (1892) 632; SAVILLE-KENT (1893) 233, 237; H. L. CLARK (1921) 177, (1932) 231, (1946) 435; DOMANTAY (1933) 71, *pl. 4, fig. 1;* MORTENSEN (1934) 6; PANNING (1944) 13.
Holothuria pluricuriosa DEICHMANN (1937) 166, *text fig. 1.*
Holothuria pseudo-zacae CHERBONNIER (1951) 23, *pl. 6, figs. 1–19, 21.*
Mertensiothuria fuscocinerea (Jaeger) DEICHMANN, E. (1958) 300–301, *pl. 3, figs. 13–23.*

Has a handsome coloration in life. Color in preserved state, grayish yellow. With six dark broad transverse bands alternated by lighter ones on dorsal side. Integument dotted with olive grayish yellow and in some cases papillæ surrounded by dark rings. Papillæ on dorsal surface and pedicels on ventral side. Each lateral and dorsal interambulacra with irregular series of low tubercles surmounted by papillæ about six in each row. Other papillæ small. Pedicels on ventral side somewhat arranged in five single rows, though not very distinct.

In 1953 the writer described this species under *H. curiosa* after Panning 1935, who apparently followed Ludwig in 1875. H. L. Clark in all his papers followed Jaeger who first described the species under *H. fuscocinerea.* The writer after considering the laws of priority concurs with H. L. Clark, hence using the same name he used in 1953, although in his recent papers he used the synonym of *H. curiosa.*

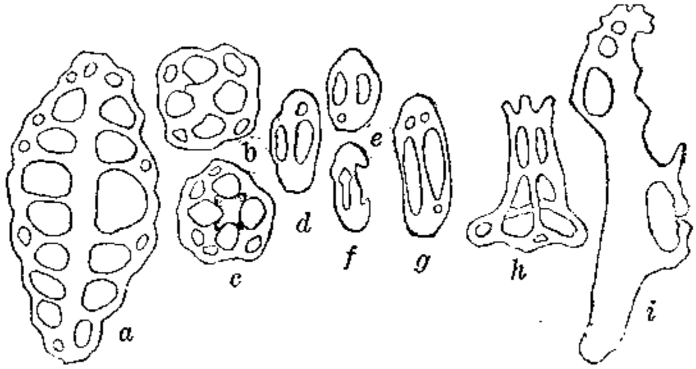

FIG. 9. *Holothuria fuscocinerea* Jaeger: *a*, supporting plate from tube foot. Average actual length 0.14 mm; *b–c*, bottom and top views of table from body wall, average actual diameter of disk 0.036 mm; *d–g*, imperfect irregular buttons from body wall, average actual length 0.03 mm; *h*, side view of a table from body wall, average actual height 0.025 mm; *i*, supporting rod from tube foot, average actual length 0.16 mm.

HOLOTHURIA FUSCOCINEREA var. PERVICAX Selenka. **Fig. 10a–h.**

Holothuria fusco-cinerea LAMPERT (1885) 64; ERWE (1913) 379, *pl. 6, fig. 16a-d;* PEARSON (1913) 74, *pl. 10, fig. 15.*

Holothuria pervicax SELENKA (1867) 327, *pl. 18, fig. 54;* SEMPER (1868) 92, 251, 279, (1869) 120; LUDWIG (1883) 156, 173; LAMPERT (1885) 62, *fig. 25;* THEEL (1886a) 213; LUDWIG (1887c) 32, (1889–92) 330, (1899) 560; LUDWIG & BARTHELS (1892) 632; SLUITER (1894) 104, (1901) 9; LAMPERT (1896) 53; FISHER (1907) 655, *pl. 68, fig. 2;* MITSUKURI (1912) 128, *text fig. 23;* H. L. CLARK (1921) 181, (1925a) 104, (1932) 234, (1946) 428; SCHMIDT (1930) 416.

Holothuria fusco-cinerea var. *pervicax* BEDFORD (1898) 837–838, *pl. 52, fig. 2a, b.;* PANNING (1944) 13.

Holothuria fusco-cinerea var. *philippinensis* DOMANTAY (1933) 71, *pl. 1, fig. 7.*

Holothuria curiosa var. *pervicax* DOMANTAY (1957) 32.

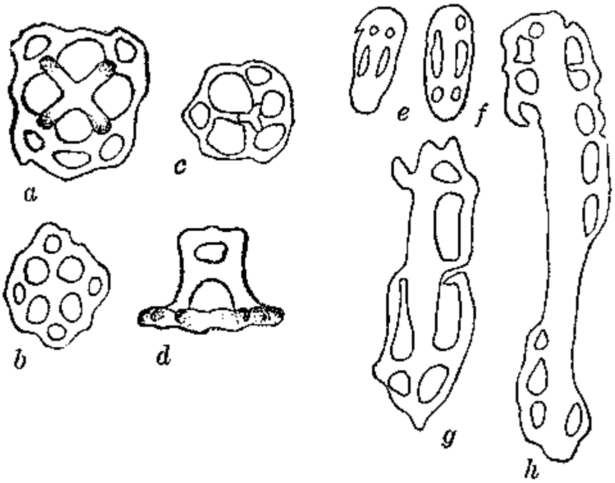

FIG. 10. *Holothuria fuscocinerea* var. *pervicax* Selenka: *a* and *c*, top view of a large and small tables from body wall; *b*, bottom view of a small table from body wall, average actual diameter of disk 0.05 mm; *d*, side view of a small table from body wall, average actual height 0.04 mm; *e* and *f*, irregular buttons from body wall, average actual length 0.04 mm; *g* and *h*, supporting rods from tube foot, average actual length 0.13 mm.

The writer believes that his new variety described in 1933 really belongs to this variety of *pervicax.* The spicules illustrated by Panning in his September 1935, page 6, text-fig. 109 for variety *pervicax* agree very well with the writer's variety *philippinensis.* With numerous low tubercles, with papillæ on dorsal and lateral sides. Dark brown papillæ encircled with lighter ring at base. General ground color of dorsal surface brown, with 6 and 7 ventral lateral extensions. Ventral side almost white.

HOLOTHURIA BIVITTATA Mitsukuri. Fig. 11a–h.

Holothuria bivittata MITSUKURI (1912) 68, *pl. 3, fig. 31, text fig. 15;* DOMANTAY (1953b) 112–113, (1957) 32.

Bohadschia marmorata bivittata PANNING (1944) 10, 42.

Holothuria (Bohadschia) bivittata PANNING (1929) 123, *text fig. 4.*

Body-wall thick and hardy. Purplish brown intermixed with numerous irregular ramifying blotches on dorsal, and almost white on ventral surface. Size 300 mm long more or less. Pedicels somewhat arranged in rows on ventral side and papillæ scattered all over dorsal surface. Commercially used for beche-de-mer.

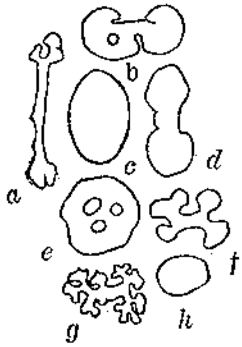

FIG. 11. *Holothuria bivittata* Mitsukuri: *a–h*, various forms of rosettes from simple granulelike to complex form from body wall.

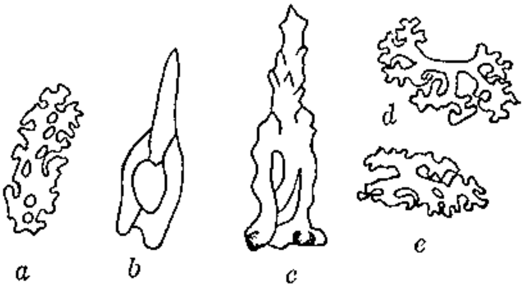

FIG. 12. *Holothuria graeffei* Semper: *a*, *d–e*, rosettelike spicules from body wall; *b–c*, trident-shaped towerlike spicules from body wall.

HOLOTHURIA GRAEFFEI Semper. Fig. 12a–e.

Bohadschia graeffei PEARSON (1944); PANNING (1944) 44, *text fig. 13.*

Holothuria troschelli MULLER (1885).

Holothuria (Bohadschia) graeffei PANNING (1929).

Holothuria graeffei SEMPER (1868); LAMPERT (1885); LUDWIG (1882); THEEL (1886); KOEHLER (1895); SLUITER (1901); KONINGSBERGER (1904); PEARSON (1913); DOMANTAY (1933) 64, (1957) 32.

With 25 to 27 large stout peltate tentacles with black stalks. Body sub-cylindrical slightly flattened ventrally; mouth surrounded by a rim of papillæ. Ground color in life violet brown with slight shades of orange and numerous small dark spots scattered over body. With some irregular dark brown blotches chiefly around papillæ and many short black striations at interpapillar spaces.

Deposits consist of rosettelike fenestrated plates, a trident-shaped towerlike spicules or imperfectly developed table and simple irregular partly knobbed rod.

Key to the species of Actinopyga Bronn

A. Tentacles 25 or more; calcareous particles rods, rosettes, and smooth oval grains .... *mauritiana*

AA. Tentacles 20 or fewer:

  B. Large species, commonly up to 200 mm or more long; deposits rods (often branched) and rosettes:

    C. Area around anus conspicuously light colored; no large rods among deposits .... *lecanora*

    CC. Area around anus not noticeably different from rest of dorsal surface:

      Large rods, often branched at ends, sometimes with lateral branches occur abundantly among countless rosettes. *echinites*

      No large rods, rosettes minute, often incomplete, not usually crowded .... *miliaris*

ACTINOPYGA LECANORA (Jaeger). Fig. 13a-g.

Mulleria lecanora JAEGER (1833) 12, *pl. 2, fig. 2; pl. 3, fig. 8;* SELENKA (1867) 312; SEMPER (1868) 75, *pl. 30, fig. 7;* HAACKE (1880) 46; LUDWIG (1881) 592, (1882) 134, 1883) 165, (1887d) 1223, (1889-92) 329; LAMPERT (1885) 100; THEEL (1886a) 200; SLUITER (1887) 200, (1894) 104, (1895) 79, (1901) 23; KOEHLER (1895a) 380; MITSUKURI (1896) 412, (1912) 45; KONINGSBERGER (1904) 37, *pl. 9;* DOFLEIN (1904) 126; VANEY (1905) 190; KOEHLER & VANEY (1908) 22; PEARSON (1910a) 173.

Actinopyga lecanora lecanora PANNING (1944) 10, 12.

Holothuria dubia BRANDT (1825) 54; SELENKA (1867) 331; SEMPER (1868) 92, 279.

Actinopyga lecanora BRONN (1860) *pl. 45, fig. 10;* SAVILLE-KENT (1893) 235; BEDFORD (1899) 149; PEARSON (1914b) 182, *pl. 29, fig. 9;* PANNING (1941) 3-5, *text fig. 1-2;* H. L. CLARK (1946) 441; DOMANTAY (1957) 32.

Upper surface of body dark brown and speckled with lighter color tiny spots. Ventral side yellowish. With 20 tentacles and papillæ on dorsal side and pedicels on ventral, arranged in three rows. Average length 200 mm. Commercially used for beche-de-mer.

ACTINOPYGA ECHINITES (Jaeger). Fig. 14a-c.

Mulleria echinites JAEGER (1833) 17, 18, *pl. 3, fig. 6;* SELENKA (1867) 312; SEMPER (1868) 76, 276, *pl. 30, fig. 8;* LUDWIG (1882) 134, (1887d) 1224, (1889-92) 329, (1899) 557; LAMPERT (1885) 99,

(1896) 59; THEEL (1886a) 201; SLUITER (1894) 104; WHITELEGGE (1897) 160, (1903) 13; PEARSON (1910a) 191; ERWE (1913) 336, *pl. 6, fig. 11;* MITSUKURI (1912) 43.

Holothuria (Actinopyga) echinites PANNING (1929) 129, *text fig. 12.*

Actinopyga echinites echinites PANNING (1944) 10, 12.

Actinopyga echinites SAVILLE-KENT (1893) 236; BEDFORD (1898) 835–836; PEARSON (1914b) 183, *pl. 29, fig. 7;* DOMANTAY (1933) 53–54, *pl. 4, fig. 5,* (1953a) 136, (1953b) 110, 120, (1957) 32; PANNING (1941) 5–7, *text fig. 3–4,* (1944) 9; H. L. CLARK (1946) 441.

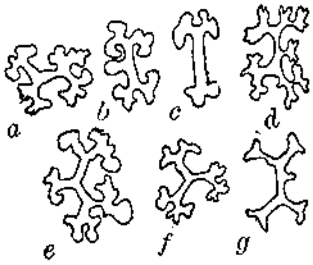

FIG. 13. *Actinopyga lecanora* (Jaeger): *a–g,* various forms of rosettes from body wall.

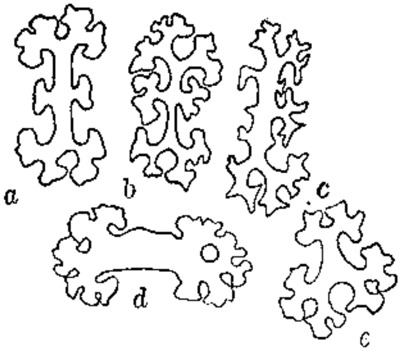

FIG. 14. *Actinopyga echinites* (Jaeger): *a–c,* various rosettes from body wall.

A large species with a length of 300 to 350 mm. Color in life dark reddish-brown to almost black on dorsal surface and lighter on ventral side. The Panakalan forms in western part of Lingayen Gulf mostly black in color and do not change in preserved state. Cylindrical and stout, and in some cases, contract almost like a ball. Two of them were collected from Hundred Islands under this condition and were suspected to be another species when no spicules could be found in the beginning. Later when examined more carefully for spicules it revealed its true species. Deposits composed of large rods, often branched at ends, sometimes with lateral branches that occur abundantly among countless rosettes. Highly commercialized for a first grade beche-de-mer.

ACTINOPYGA MAURITIANA (Quoy & Gaimard). **Fig. 15a–e.**

Holothuria mauritiana QUOY & GAIMARD (1833) 138; SELENKA (1867) 315, (1868) 117; SEMPER (1868) 76, 276, (1869) 120; LUDWIG (1882) 134, (1887e) 26, (1888) 812, (1899) 557; LAMPERT (1885) 98; THEEL (1886a) 201.

Mulleria mauritiana Ludwig (1883) 157, 165, (1887b) 199, (1896) 7, (1901) 24; Lampert (1889) 813, (1896) 59, Koehler (1895a) 380; Koehler & Vaney (1908) 22; Pearson (1910a) 174, *text fig.* 16; Mitsukuri (1912) 53, *pl. 3, 22, figs. 25–27, text fig. 11.*

Mulleria varians Selenka (1867) 310, *pl. 17, figs. 4–9.*

Holothuria (Actinopyga) mauritiana Panning (1929) 128, *text fig. 11.*

Actinopyga mauritiana Bell (1887c) 653, *pl. 39, fig. 1;* Saville-Kent (1893) 229, 236; Bedford (1898) 835, (1899) 149; Pearson (1903) 199, (1914) 185, *pl. 29, fig. 8;* Fisher (1907) 648, *pl. 67, fig. 1;* H. L. Clark (1925) 105, (1946) 440; Domantay (1933) 51, *pl. 1, fig. 4,* (1953a) 136, (1954a) 338, 349–350, (1957) 32; Panning (1941) 7–10, *text figs.* 5–6, (1944) 9, 10, 12.

A common species found in all Philippine waters, with 25 tentacles. Body length 300 mm or longer. Natural coloration dark brown on dorsal side speckled with tiny dark spots with some straitions. Anal region around anus with irregular white blotches which may be absent in some. Like all other species of *Actinopyga,* anal opening characterized by presence of five calcareous teeth, very prominent in this particular species. Papillæ on dorsal side and pedicels on ventral. Body thick and hardy. Commercialized for beche-de-mer.

Deposits composed of calcareous particles of rods, rosettes and tiny smooth oval grains.

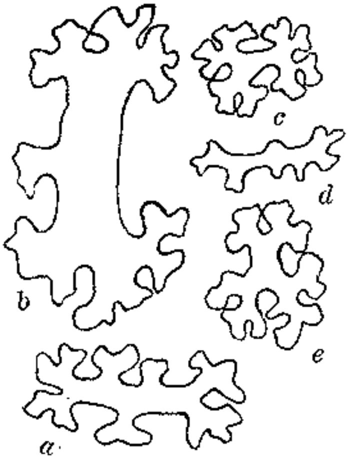

Fig. 15. *Actinopyga mauritiana* (Quoy & Gaimard): *a–e,* various rosettes from body wall, average actual length 0.07 mm.

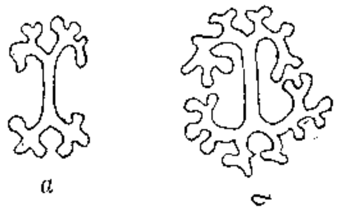

Fig. 16. *Actinopyga miliaris* (Quoy & Gaimard): *a,* simple rosette; *b,* complex rosette.

ACTINOPYGA MILIARIS (Quoy & Gaimard). **Fig. 16a-b.**

Holothuria miliaris Quoy and Gaimard (1833) 137.

Mulleria miliaris Brandt (1835) 74; Selenka (1867) 314, (1868) 117; Semper (1868) 76, 276; Ludwig (1880) 7, (1882) 134, (1883) 165, (1887a) 144, (1888) 812, (1889–92) 329, (1899) 557; Haacke (1880) 46; Lampert (1885) 99; Theel (1886a) 200; Sluiter (1894) 104, (1895) 79, (1901) 23; Koehler & Vaney (1908) 22; Pearson (1910a) 175.

Holothuria lineolata Quoy & Gaimard (1833) 137–138; Brandt (1835) 74; Selenka (1867) 314.

Mulleria plebeja Selenka (1867) 312.

Actinopyga lecanora miliaris Panning (1944) 10, 12.

Actinopyga miliaris Bell (1887e) 653, *pl. 40, fig. 1,* (1888) 389; Pearson (1914b) 181; *pl. 29, fig. 6;* Domantay (1933) 53, *pl. 4, fig. 6,* (1953a) 136, (1953b) 110, 120-121, (1957) 32; H. L. Clark (1946) 441.

Like other species of *Actinopyga* body elongate, ovate and robust, slightly arched dorsally and flattened ventrally. Ventral surface with three distinct rows of pedicels. Papillæ scattered irregularly on dorsal side. Color orange brown with a large chestnut brown blotch on dorsal side near anal region. When animal strongly contracted, dark brown color appears almost black in some specimens. Body wall hardy and does not apparently grow very big. Deposits composed of numerous tiny rosettes, x-shaped rosettes with dichotomous bifurcations and some spinous rods. Commercialized for beche-de-mer.

ARGIODIA MACULATA Brandt. **Fig. 17a-f.**

Mulleria nobilis Selenka (1867) 313, *pl. 17, figs. 13–15;* Semper (1868) 76, 276, *pl. 37, figs. 9–12;* (1869) 120, Theel (1886) 198.

Holothuria maculata Brandt (1835) 54; Selenka (1867) 331; Semper (1868) 92, 279.

Mulleria maculata Ludwig (1881) 593, (1889–92) 359, (1899) 557; Lampert (1885) 97; Mitsukuri (1912) 48, *pl. 3, fig. 23–24, text fig. 10;* Erwe (1913) 368, *pl. 6, fig. 12.*

Mulleria hadra Selenka (1867) 313, *pl. 17, fig.* 16; Lampert (1885) 97; Theel (1886a) 198.

Actinopyga nobilis Fisher (1907) 647; H. L. Clark (1946) 440.

Actinopyga maculata Bedford (1899) 150; Domantay (1957) 32.

Holothuria (Microthele) nobilis Panning (1929) 131–132, *text fig. 15.*

Argiodia flavo-castanea Pearson (1914b) 176, *pl. 28, fig. 3.*

Microthele nobilis Domantay (1953a) 136, (1953b) 110, 122–123; Panning (1941) 10–13, *text figs.* 7–8, (1944) 9, 10, 12.

Argiodia maculata Pearson (1914a) 170, (1914b) 174, *pls. 27–28, fig. 2;* Domantay (1933) 55–56, *pl. 1, fig. 1.*

This species has been reported under many synonyms. The writer himself has decided to use the old name he reported in 1933 although in his recent papers he used *Microthele nobilis* (Selenka). Brandt was the first to describe the species under *Holothuria maculata* in 1835 whereas Selenka described it in 1867 under *Mulleria nobilis*. Pearson in 1913 split *Mulleria* into *Actinopyga* and *Argiodia*. The calcareous deposits of this particular species would not warrant it to be under *Actinopyga* hence the genus *Argiodia* would be the correct one to adapt.

Body with dorsal and ventral sides well marked off, rounded at both ends, with five large conspicuous conical protuberances along each ventro-lateral sides. Few papillæ sparsely scattered on dorsal surface and pedicels arranged in three indistinct bands on ventral side. Color in life dark brownish-gray to almost black dorsally and much lighter ventrally. Deposits composed of tables, hollow fenestrated ellipsoids and numerous knobbed buttons. Highly commercialized for beche-de-mer.

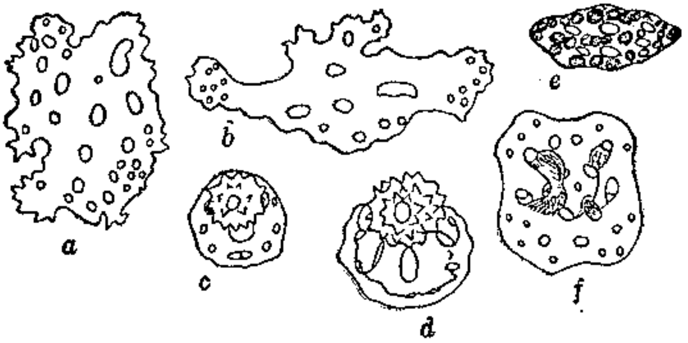

FIG. 17. *Argiodia maculata* (Brandt): *a–b*, supporting plates from tube foot, average actual length 0.17 mm and width 0.14 mm; *c–d*, small and large tables from body wall, average actual diameter of disk 0.07 mm, diameter of spire 0.04 mm and height 0.05 mm; *e*, fenestrated ellipsoid from body wall, average actual length 0.055 mm; *f*, table with rudimentary spire from body wall, average actual diameter of disk 0.09 mm.

Family STICHOPIDÆ Brandt, 1835

GENUS STICHOPUS Brandt, 1835

Key to the species of Stichopus

A. No buttons among calcareous deposits.
  B. Few Rosettes or none among calcareous deposits, with tables and C-shaped spicules:
    C. Tables with regular spires, smooth disk, and smaller C-shaped spicules, with few or practically no rosettes .... *chloronotus*

BB. Many rosettes present:
  D. Large tables, some with heavy, smooth conical spire from dorsal papillæ .... *horrens*
  DD. No large tables with conical spire:
    Large species with variegated coloration of olive gray with different shades of green and yellow .... *variegatus*
    Body ground color homogenous greenish brown or greenish orange with shades of brown; supporting rod from tube foot with more ranifications and some small spinous ones. *variegatus* var. *hermanni*

STICHOPUS CHLORONOTUS Brandt. Fig. 18a-g.

Stichopus cylindricus HAACKE (1880).

Stichopus chloronotus BRANDT (1835); SELENKA (1867); LUDWIG (1882), (1887); LAMPERT (1885); BELL (1886); THEEL (1886); SLUITER (1887), (1901); SAVILLE-KENT (1893); PEARSON (1903); FISHER (1907); KOEHLER and VANEY (1903); H. L. CLARK (1921), 186, *pl. 18, fig. 2.* (Colored), (1946) 417; SIVICKIS and DOMANTAY (1928); DOMANTAY (1933) 77–78. *pl. 3, fig. 2,* (1955a) 136, (1954a) 338, 351–352, (1957) 32; PANNING (1944) 8, 10, 12, 30-3, *text fig. 3.*

Medium-sized species, seldom exceeding 300 mm long with elongate and quadrangular body tapered at both ends. Dorso and ventro-lateral ambulacral angles with double rows of conical papillæ alternatively arranged, with pedicels arranged in three rows ventrally. Color in life dark green or bluish green

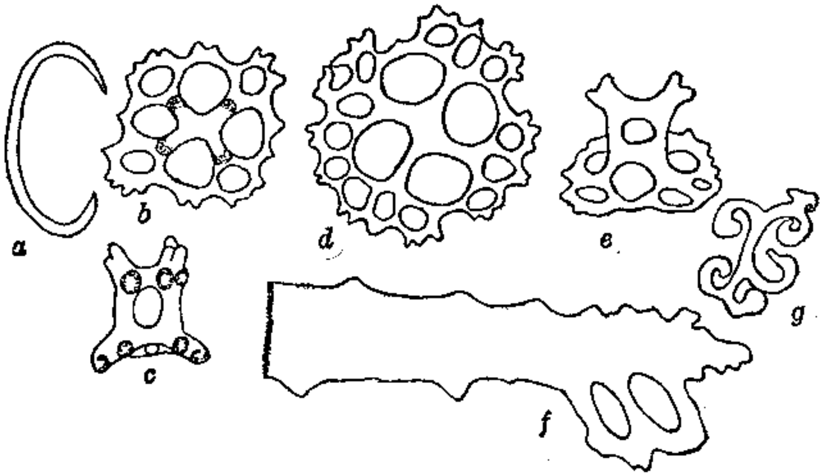

FIG. 18. *Stichopus chloronotus* Brandt: *a*, C-shaped spicule from body wall, average actual length 0.044 mm; *b*, top view of a table from body wall, average actual diameter of disk 0.037 mm; *c* & *e*, side view of a table, average actual height 0.037 mm; *d*, bottom view of a large table, average actual diameter of disk 0.056 mm; *f*, portion of a supporting rod from tube foot, average actual length of entire rod 0.37 mm; *g*, rosette from body wall.

to almost blue black at a distance. Body apparently hardy but when removed from the water it easily disintegrates and decomposes when pressed mechanically.

Deposits composed of tables, C-shaped spicules and few rosettes. Pedicels with supporting rods. No commercial value and not edible.

STICHOPUS VARIEGATUS Semper. Fig. 19a–g.

Stichopus variegatus SEMPER (1868) 72; H. L. Clark (1946) 418; DOMANTAY (1933) 79–80, *pl. 2, fig. 1*, (1953a) 136, (1953b) 110, 123–124, (1957) 32; PANNING (1944) 8, 10, 12, 31–33, *text fig. 4*.

Large species with elongate and quadrangular body. Like other *Stichopus*, dorsal side distinctly well marked off from ventral. Pedicels distinctly arranged in three rows ventrally. Color in life olive gray with different shades of green and yellow and some fine black striations running irregularly on dorsal surface with tip of papillæ dark pink. Common size encountered 200 mm long and 50 mm wide and 30 mm thick although biggest recorded by Semper 900 mm long by 200 mm wide. No commercial value. Deposits composed of tables, rosettes, C-shaped spicules, and supporting rods in the pedicels.

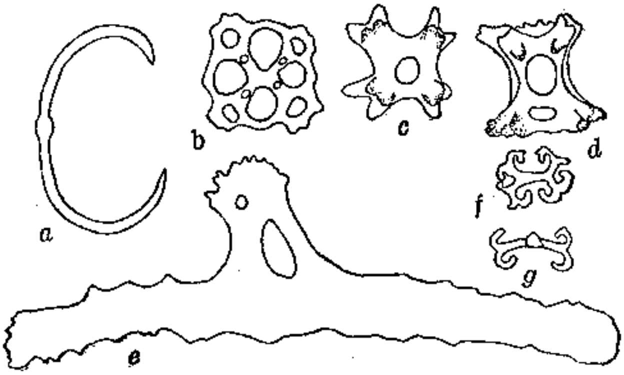

FIG. 19. *Stichopus variegatus* Semper: *a*, C-shaped spicule from body wall, average actual length 0.074 mm; *b*, bottom view of a table, average actual diameter of disk 0.04 mm; *c*, top view of a spire of table, average actual diameter 0.019 mm; *d*, side view of a table, average actual height 0.03 mm; *e*, supporting rod from a tube foot, average actual length 0.37 mm; *f–g*, rosettes from body wall, average actual length 0.03 mm.

STICHOPUS VARIEGATUS var. **HERMANNI** Semper. Fig. 20a–b.

Stichopus variegatus var. *hermanni* SEMPER (1868) 73, *pl. 17, 30, fig. 2*; H. L. CLARK (1922) 68; DOMANTAY (1933) 80–81, *pl. 2, fig. 2*, (1953b) 124, (1957) 32; PANNING (1944) 33.

Resembles the straight species in size and shape with several differences in coloration as well as in the supporting rods of pedicels. Body ground color homogenous greenish brown or greenish orange with shades of brown, and with many fine incomplete dark green striations on dorsal surface. Tip of papillæ bright scarlet red. Deposits similar to preceding straight species except in some minor differences. With two types of supporting rods from tube foot, one smaller spinous and the bigger ones with more ramifications. No commercial importance.

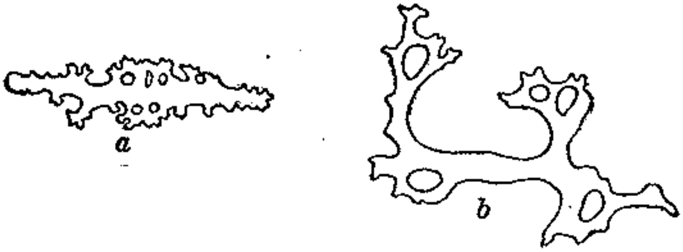

FIG. 20. *Stichopus variegatus* var. *hermanni* Semper: *a*, small spinous supporting rod from tube foot; *b*, a portion of supporting rod from tube foot, average actual length of entire rod 0.31 mm. Other forms of spicules similar to the straight species.

STICHOPUS HORRENS Selenka. Fig. 21a-k.

Stichopus godeffroyi SEMPER (1868) 75, *pl 30, fig. 4.*
Stichopus godeffroyi var. *pygmaeus* SEMPER (1868) 75.
Stichopus godeffroyi var. *b*. SEMPER (1868) 246.
Stichopus tropicalis FISHER (1907) 676, *pl. 70, figs. 1–11.*
Stichopus horrens SELENKA (1867) 316, *pl. 18, figs. 27–29;* H. L. CLARK (1921) 187, *pl. 18, fig. 4,* (1922) 64–66, *pl. 2, figs.* 19–23; DOMANTAY (1933) 78–79, *pl. 3, fig. 1,* (1953a) 136, (1953b) 110, 125, (1954a) 338, 352, (1957) 32; PANNING (1944) 35.

Medium-sized species from 100 to 200 mm long. Young and small specimens with delicate body-wall, almost transparent. In bigger specimens, body color somewhat olive-green, mottled with white and darker shades dorsally and cream color ventrally. Slightly variegated in some with white, gray, brown, and black. Body-wall easily disintegrates and hard to preserve in perfect condition. No commercial value. With two types of tables, small and large, some of the large ones with conical spines; numerous rosettes and C-shaped spicules. Supporting rods from tube foot with perforated plate at middle.

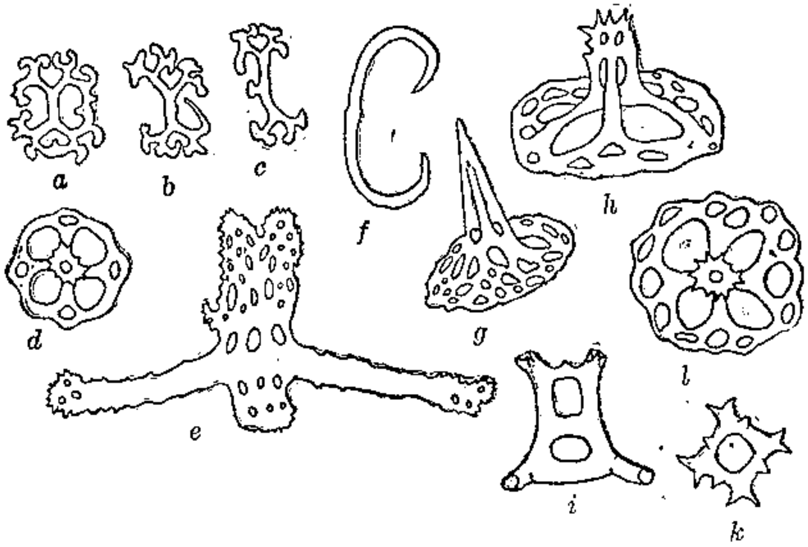

FIG. 21. *Stichopus horrens* Selenka: *a–c*, rosettes from body wall, average actual length 0.038 mm and width 0.029 mm; *d*, top view of a small table from body wall, average actual diameter of disk 0.057 mm; *e*, supporting rod plate from tube foot, average actual length 0.35 mm and width of perforated plate 0.2 mm; *f*, C-shaped spicule from body wall, average actual length 0.14 mm; *g*, side view of a large truncate table from body wall, average actual height 0.12 mm and diameter of disk 0.15 mm; *h*, side view of a large table from body wall, average actual height 0.056 mm; *i*, side view of small table, average actual height 0.029 mm; *j*, top view of similar table with average actual diameter of disk 0.08 mm; *k*, top view of spire of a similar table, average actual width of spire 0.019 mm.

Family PHYLLOPHORIDÆ

Genus THYONE Oken, 1915

THYONE BUCCALIS LOURDESÆ subsp. nov. Fig. 22a o.

Body crescent-shape, 40 mm long and 6 mm diameter at middle region, slightly tapered at both ends, with both oral and anal openings turned upward. Oral end with 8 large dendroid tentacles and 2 smaller ones encircling the mouth Fig. 22, g. The 2 smaller tentacles very much reduced in size and ventrally located. Tentacles surrounding oral opening constitute a distinct pharyngeal lobe well marked off from the body, apparently non-retractile considering its large size compared with the tapered end of the body. Junction between pharyngeal lobe and body weak and usually break off when the former autotomize upon excitation. Pharyngeal lobe tender and soft

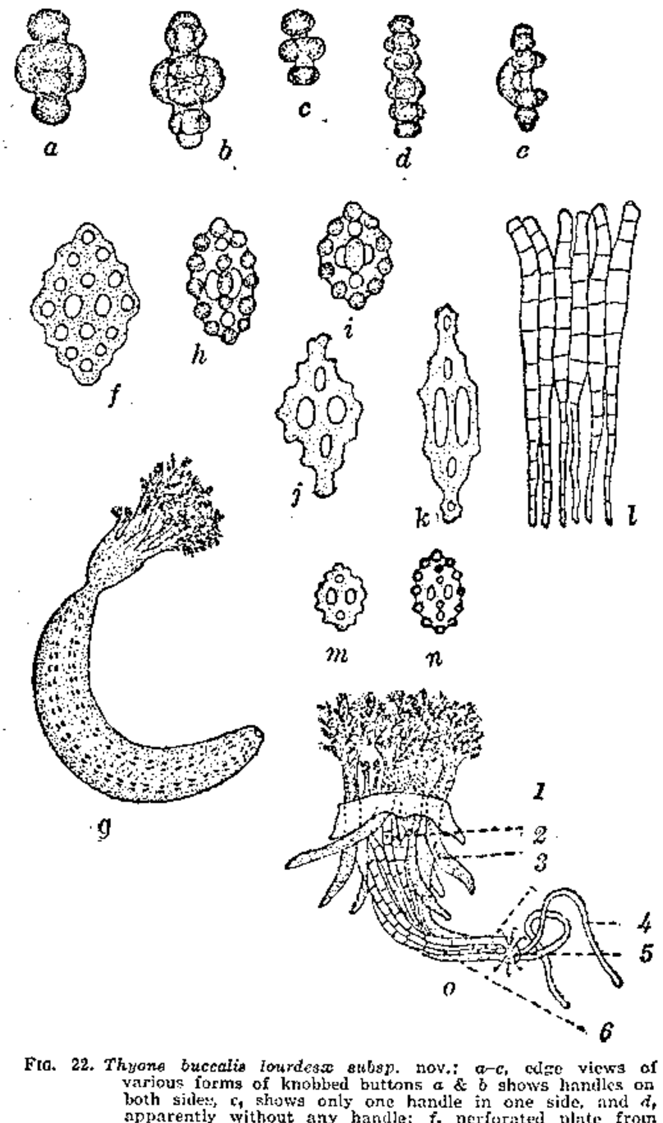

FIG. 22. *Thyone buccalis lourdesæ subsp.* nov.: *a–c*, edge views of various forms of knobbed buttons *a* & *b* shows handles on both sides, c, shows only one handle in one side, and *d*, apparently without any handle; *f*, perforated plate from tube foot; *g*, side view of the entire animal showing the two distinct parts of body, the anterior pharyngeal lobe and the posterior crescent-shaped body; *h–i*, surface views of knobbed buttons from body wall; *j*, perforated plate from pharyngeal lobe; *k*, supporting plate from tube foot; *l*, calcareous pharyngeal ring located within the paryngeal lobe: *m*, surface view of a lighter form of buttons from the crescent-shaped body wall; *n*, surface view of a lighter knobbed button from the crescent-shaped body wall; *o*, pharyngeal lobe exposed from inside to show the relations of the calcareous pharyngeal ring, the ampulæ of tentacles, and other parts of the water-vascular system: *1*, calcareous pharyngeal ring; *2*, tentacular ampulla; *3*, madreporic body; *4*, polian vesicle; *5*, water ring canal, *6*, posterior prolongations of calcareous ring.

compared with the hardly crescent-shaped body loaded with numerous packed spicules. Anal opening with 5 conspicuous papillæ giving as stellate opening. At both ends of body, pentameroid arrangement of paired rows of pedicels distinct, but obliterated at middle part and irregularly arranged, apparently due to the partly contracted condition of body. Natural color in life variegated brown dorsally and dirty white ventrally. In preserved state much paler and even becomes white in long state of preservation.

The snapping off of its pharyngeal lobe when irritated enabled the writer to study its internal structures partially without dissecting the body. Tentacles with prominent tubular tentacular ampullæ, Fig. 22, 0–2, the 2 smaller ones apparently without them. Calcareous ring with very long paired posterior prolongations on the radials Fig. 22, 0–6. At distal tips of paired prolongations of calcareous ring is pharyngeal water ring canal of the water vascular system Fig. 22, 0–5. Attached to it are two long tubular Polian vesicles Fig. 22, 0–4, and six tiny stone canals Fig. 0–3 of the water-vascular system, each with a small madrepore body.

Deposits: Skin of pharyngeal lobe soft and delicate, provided with perforated plates of different sizes, characterized by two large oval holes at middle and smaller ones at periphery Fig. 22, j. Skin of the crescent-shape body loaded with packed knobbed buttons of two types, one with heavy type knobs apparently fully formed spicules and another of lighter form, thinner, of various sizes which apparently are in early stages in formation of heavy knobbed buttons Fig. 22, a–e, h–i. The heavy type knobbed button with a handle or an arch on one side or both surfaces of the button Fig. 22, a, b, e. Some without it entirely. The heavy knobbed button with an arch or handle on both sides is the typical characteristic feature of the straight species described by Selenka in 1867 in his *Stolus sacellus*. Intermixed with these packed knobbed buttons are few large rosettes of different pattern not reported in the straight species mentioned above. Tip of pedicel with end-plate Fig. 22, f. surrounded by numerous curved supporting plates without spire, and spindle-shape, perforated at both ends, and with two large elongated holes at middle Fig. 22, k.

Two specimens taken from inside a coral rock when broken off. One located nearer surface, completely hidden and other one burried deep in middle of rock where a Gorgonacean, *Rumphella aggregata* (Nutting) is attached. This is the first time the writer encountered this genus from among the Philippine materials although Semper in 1868 reported *Thyone regida*, a synonym of *Stolus sacellus*. H. L. Clark in 1946 considered the two synonyms as the same species of *Thyone bucculis* from Australia. Stimson in 1855 was the first one to describe this species in the Proceedings of the Academy of Natural Science of Philadelphia, volume 7, page 386. Other synonyms of the straight species are *Stereoderma murrayi* by Bell 1883 and *Thyone sacellus* by Erwe 1913.

This new variety of *Thyone buccalis* var. *lourdesæ* reminded the writer of his *Neothyonidium magnum* (*Phyllophorus magnus* Ludwig) he reported in 1933 from Puerto Galera. The two belong to the same family. The latter is usually burried in sandy rocky bottom with the U-shaped body and with the pharyngeal lobe at the proximal limb of the body.

Type.—Holotype, Acc. No. 590.

Type locality.—Panakalan Islet vicinity.

Distribution.—In type locality.

Depth.—5 fathoms.

Order APODA Brandt, 1835

Family SYNAPTIDÆ Ostergren, 1905

Genus **SYNAPTA** Eschscholtz, 1829

SYNAPTA MACULATA (Chamisso and Eysenhardt). Fig. 23.

Holothuria maculata CHAMISSO and EYSENHARDT (1821) 352.
Synapta mammillosa ESCHSCHOLTZ (1829); JAEGER (1833).
Holothuria oceanica LESSON (1830).
Synapta beselii JAEGER (1833); SEMPER (1868); THEEL (1886a); TENNISON-WOODS (1880).
Synapta oceanica JAEGER (1833).
Synapta astrolabi HELD (1857).
Chondrochloea beselii OSTERGREN (1898b).
Synapta maculata JAEGER (1833); H. L. CLARK (1908) 78, *pl. 1* (colored), (1946) 450, (1924) 471–473, *pl 3, fig. 1–2, pl. 4, fig. 1, pl. 5;* DOMANTAY (1933) 89–90, *pl. 2, fig. 7,* (1953a) 139, (1953b) 110, 126–127, (1954a) 338, 353–354, (1957) 32.

Longest species among the Synaptids, measuring two meters more or less, and in some, reaches 3 meters when fully extended. Color in life with five distinct longitudinal bands of two or three different colors crossed by incomplete irregular bands of variegated brown of darker and lighter shades alternated by black. Body surface rough and sticks to the skin when handled due to large anchors sticking outward from the skin. At times when external condition becomes abnormal body forms prominent folds in alternation along whole length known as *verrucæ,* which vary greatly with size and nature of contraction of animal. Deposits composed of large anchors and anchor-plates and numerous miliary granules. No commercial value.

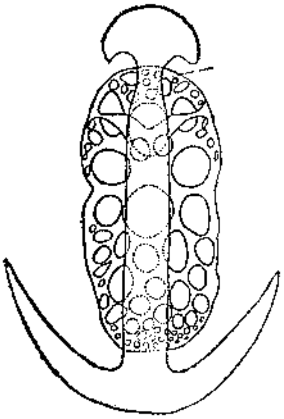

FIG. 23. *Synapta maculata* (Chamisso & Eysenhardt): anchor and anchor-plate in their natural position from body wall, average actual length of anchor 1.12 mm. and anchor-plate 0.8 mm.

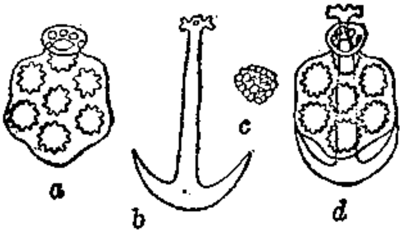

FIG. 24. *Opheodesoma grisea* (Semper): *a*, anchor-plate from body wall, average actual diameter 0.18 mm; *b*, anchor from body wall, average actual length from stock to vertex 0.26 mm and length of arm 0.1 mm; *c*, miliary granule from body wall, average actual diameter 0.015 mm; *d*, anchor and anchor-plate in their natural position.

Genus **OPHEODESOMA** Fisher, 1907

OPHEODESOMA GRISEA (Semper).

Fig. 24a-d.

Synapta grisea SEMPER (1868) 11, *pl. 4, figs. 6–7.*
Opheodesoma spectabilis var. *puerto-galeræ* DOMANTAY (1933) 86–87, *pl. 2, fig. 10,* (1953a) 139; (1953b) 110, 126–127, (1957) 32.
Opheodesoma spectabilis DOMANTAY (1957) 32.
Opheodesoma grisea FISHER (1907) 723; H. L. CLARK (1924) 466, *pl. 2, figs. 1–3,* (1946) 449.

Small species of Synaptid, usually a foot long more or less, with very slender body. Body-wall thin and rough to touch due to anchors of skin. When external condition becomes abnormal, integument may show five regular series of numerous folds of *verrucae* extending entire length of body. Color in life brownish-green to dark green with some irregular longitudinal lighter strips with numerous minute white specks. Variation of color pattern may be seen in some specimens but general ground color almost same. Deposits composed of small anchors, anchor-plates and miliary granules. No commercial value.

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It would be most ungracious if the writer failed to express his most sincere appreciation to all those whose assistance has made the present work possible:

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BIBLIOGRAPHY

CLARK, H. L. Notes on the Bermuda echinoderms. New York Acad. Sci. Ann. 11 (1898).

CLARK, H. L. Further notes on the Bermuda echinoderms. New York Acad. Sci. Ann. 12 (1890).

CLARK, H. L. The apodous holothurians: a monograph of the Synaptidæ and Molpadidæ, etc. Wash. D. C., Smith Inst. Cont. to Knowledge 35 (1907).

CLARK, H. L. The echinoderm fauna of Torres Strait: Its composition and its origin. Carnegie Inst. Wash. Dept. Mar. Biol. Paper 10 (1921).

CLARK, H. L. The holothurians of the genus Stichopus. Mus. Comp. Zool. Bull. 65 (1922).

CLARK, H. L. Notes on a collection of echinoderms from the Australian Museum. Sidney, Australia. Museum, Records No. 215 (1926).

CLARK, H. L. Echinoderms from Australia. Mus. Comp. Zool. Mem. 55 (1938).

DEICHMANN, E. Holothurians from the Gulf of California. The Templeton Croaker Expedition, 9. Zoologica 22 (1937).

DEICHMANN, E. Holothurians from the western coast of Lower California and Central America, and from the Galapagos Islands Eastern Pacific Expeditions of the New York Zoological Society, 16. Zoologica 23 (1938).

DEICHMANN, E. The Holothurioidea Collected by the Velero III and IV During the Years 1932 to 1954. Part II. Aspidochirota. The University of Southern California Press, Los Angeles, California (1958).

DOMANTAY, J. S. Littoral Holothurioidea of Port Galera Bay and adjacent waters. U.P. Nat. Appl. Sci. Bull. 3 (1933).

DOMANTAY, J. S. Four additional species of littoral Holothurioidea of Port Galera Bay and adjacent waters. U.P. Nat. Appl. Sci. Bull. 4 (1934).

DOMANTAY, J. S. Some holothurians from Guam and vicinity. U. P. Nat. Appl. Sci. Bull. (4) 12 (1954) 336–357.

DOMANTAY, J. S. A brief summary of the Pacific and Atlantic Holothurioidea of the Allan Hancock Foundation Collections. Philip. Jour. Sci. 82 (1953) 133–140.

DOMANTAY, J. S. Littoral holothurians from Zamboanga and vicinity. Philip. Jour. Sci. 82 (1953) 109–131.

DOMANTAY, J. S. The zoogeographical distribution of the Indo-Pacific littoral Holothurioidea. Proc. Eight Pacific Science Congress. Nat. Res. Council of the Philippines (1957).

DOMANTAY, J. S. Preliminary report on the marine fauna of one hundred islands and vicinity, Gulf of Lingayen, Pangasinan Province, Luzon, Philippines. Araneta Jour. Agr. No. 1 4 (1957).

DOMANTAY, J. S. Some holothurians from Florida in the collection of the Allan Hancock Foundation. Agra Univ. Jour. Res. (Science) 7 (1958) 181–202; Plate 2.

FISHER, W. K. The holothurians of the Hawaiian Islands. U.S. Nat. Mus. Proc. 32 (1907).

HEDING, S. G. Contribution of the knowledge of Synaptidæ, I. Vidensk Medd. Fra Dansk Naturg. Foren. 88 (1929).

HEDING, S. G. Echinoderm III. Holothurioidea 2 (Fam. Synaptidæ) Beitrage zur Kentnis der Meeres fauna Westafrikus (7) 3 (1932).

HEDING, S. G., and A. PANNING. Phyllophoridæ eine bearbeitung der Polytentaculaten Dendrochiroten Holothurien des Zoologischen Museums in Kopenhagen. Spolia Zoologica Musei Hauniensis 13 (1954) 7–209.

KOEHLER, R., and C. VANEY. An account of the littoral Holothurioidea echinoderms of the Indian Museum, Calcutta (1908).

LUDWIG, H. The Holothurioidea: in reports on an exploration off the west coast of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U. S. Fish Commission Steamer "Albatross" Nr. 12. Mus. Harvard Coll. Mem. (3) 17 (1894).

MITSUKURI, K. Studies on actinopodous Holothurioidea. Imperial Univ. Tokyo, Jour. Coll. Sci. (2) 29 (1912).

MORTENSEN, T. Echinoderms of New Zealand and the Aukland-Compbell Island, III–V. Vidensk Medd. Dansk Naturgh, Foren. 79 (1925).

OSHIMA, H. The Synaptidæ of Japan. Annot. Zool. Jap. 8 (1914).

OSHIMA, H. Report on the holothurians collected by the Albatross, etc. U. S. Nat. Mus. Proc. 48 (1915).

PANNING, A. Echinoderm III. Holothurioidea I (Fam. Holothurioidea): In Michaelsen, W. Beitrage zur. Kenntnis der Meeresfauna, Westafrikus (5) 3 (1928a).

PANNING, A. Uber das optische Verhalten der Kalkkorper der aspidochiroten Holothurien. Zeit. Wiss. Zool. 132 (1928b).

PANNING, A. Zur Kristalloptik der Kalkkorper der asipidochiroten Holothurien Zool. Staats-Inst. 44 (1929).

PANNING, A. Die Gattung Holothuria. Mitt. a.d. Zool. Staat. u. Zoolog. Mus. Hamburg. (1929).

PANNING, A. Uber die Kristalloptik der Kalkkorper der Seewelsen. Zool. Jahrab. (2) 49 (1931).

PANNING, A. Die Gattung Holothuria. (2 teil) Zoolog. Mus. in Hamburg. Mitt. a.d. Zoolog. Staat. 45 (1934).

PANNING, A. Die Gattung Holothuria. (3 teil) Zoolog. Mus. in Hamburg. Mitt. a.d. Zoolog. Staat. 45 (1934).

PANNING, A. Die Gattung Holothuria. (4 teil) Zoolog. Mus. in Hamburg. Mitt. a.d. Zoolog, Staat. 46 (1935).

PANNING, A. Die Gattung Holothuria. (5 tiel) Zoolog. Mus. in Hamburg. Mitt. a.d. Zoolog. Staat. 46 (1935).

PANNING, A. Uber einige Ostafrikanische Seewalzen U. ihre eignung zur Trepanggewinnung. Thallassia. (8) 4 (1954) 3–18.

PANNING, A. Die Trepangfischerie. Sonderuck aus Miit. aus dem Hamburgischen Zoologischen Museum and Institute in Hamburg 49 (1944) 1–76.

PEARSON, J. Notes on the Holothurioidea of the Indian Ocean I. The genus Holothuria. Spolia Ceylanica 9 (1913).

PEARSON, J. Proposed re-classification of the genera Mulleria and Holothuria. Spolia Ceylanica 9 (1914a).

PEARSON, J. Notes on the Holothurioidea II. The sub-genera Argiodia and Actinopyga. Spolia Ceylanica 9 (1914b).

SAVILLE-KENT, W. The Great Barrier Reef of Australia: Its Products and Pontentialities, London (1893).

SEMPER, C. Holothurians. Reisen in Archipel der Philippinen, Teil 2 Wiss. Ras. Leipzig. 1 (1868).

SELENKA, E. Beitrage zur Anatomie and Systematik der Holothurien. Zeit. Wiss. Zoolog. 17 (1867).

SIVICKIS, P. B., and J. S. DOMANTAY. The morphology of a holothurian, Stichopus chloronotus Brandt. Philip. Jour. Sci. 37 (1928).

VANEY, C. Holothuries recueillies sur la Cote Francaise des Somalis. Bull. Mus. d'Histoire Nat. 2 (1905).

STERIC FACILITATION OF CHELATION IN NITRO-NAPHTHOLS *

By O. S. PASCUAL and E. J. GATCHALIAN

ONE TEXT FIGURE

Studies[1] have shown that the strength of an intramolecular hydrogen bond in an aromatic system varies with the bond order of the (aromatic) carbon-carbon bond involved in the chelation. Molecular orbital calculations[2] shows that the 1 and 2 bond in naphthalene (1.73) has a higher bond order than the 2 and 3 bond (1.6). However, in the case of 1-nitro 2-naphthol and its isomer, 2-nitro 1-naphthol, the same bond (1 and 2 bond) is involved so that bond order would be of no help in predicting nor elucidating any differences in their acid strength (relative to the unsubstituted naphthols).

Free valence[3] has been proposed to explain the difference in acid strength between *alpha*- and *beta*-naphthols.[4] The *alpha*-position, with a free valence (0.452) higher than the *beta*-position (0.404) would be more suitable for conjugation with a substituent, resulting in a larger *pi*-charge transfer from the substituent to the aromatic system. In the two isomeric nitro-naphthols, both substituents are capable of conjugation with the aromatic ring although probably to a different degree, but being linked by a bond possessing a relatively high bond order, charge transfer would be relatively easy so that both chelate structures (Figs. 1 and 2) are about equally probable.

It is with this problem in view that the ionization constants of 1-nitro 2-naphthol and 2-nitro 1-naphthol were determined. To check our experimental technique as well as the reported

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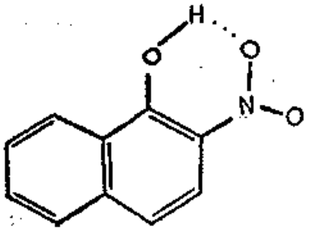
* Contribution from the Department of Chemistry, University of the Philippines.

[1] Hunsberger, I. Jour. Amer. Chem. Soc. 72 (1950) 5626; Hunsberger, I., R. Ketchem, and H. Gutowsky, ibid. 74 (1952) 4839; Hunsberger, I. et al., ibid. 77 (1955) 2466.

[2] Longuet-Higgins, H. C., and C. A. Coulson. Trans. Faraday Soc. 48 (1947) 78.

[3] Pullman, B., and A. Pullman. Les Theories Electronigues de la Chimie Organique, Paris, 1952.

[4] The ionization constants are 1.41×10^{-10} and 1.18×10^{-10} respectively.



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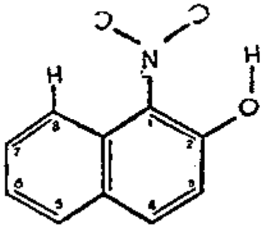

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values in the literature for *ortho-*, *meta-* and *para*-nitrophenols,[5] their ionization constants were also evaluated. The spectrophotometric technique was used. The experimented values of pK_a and K_a are tabulated in Table 1. For comparison purposes, the reported values for phenol, *alpha*-naphthol and *beta*-naphthol were also included. The more pertinent portions of the experimental data are included in Tables 2 and 3.

The observed order of the Pk_a's of the isomers, *ortho-*, *meta-*, and *para*-nitrophenols:

$$\text{meta} \gg \text{ortho} > \text{para}$$

does suggest chelation in the *ortho*-isomer, which is generally accepted. It is therefore reasonable to expect the possibility of chelation in the naphthol analog too. This is supported by the infrared studies of Hunsberger and his coworkers.[6]

The ratio K_{alpha}/K_{beta} of the unsubstituted naphthols is 1.2 which increased to 2.0 in the nitro-derivatives shows that the naphthols were not affected to the same extent on substitution with a nitro-group. There is also a 14-fold increase in the K_a of *alpha*-naphthol on substitution with a nitro-group in the 2-position and only an 8-fold increase in the *beta*-isomer. Both increases are not unexpected and are due to the electrophilic nature of the nitrogroup.

The difference in acid strength between *alpha-* and *beta*-naphthols may be attributed also to the (weak) electrophilic nature of the (fused) phenyl-group.[7] The nearer the fused ring is to hydroxyl-group, the more effective is its influence and the stronger is the phenol as an acid. Thus, locating a hydroxyl-group between two electrophilic groups (the fused phenyl-group and the nitro-group), as in 2-nitro 1-naphthol, should produce a stronger acid than when the two electrophilic groups are attached on the same side of the benzene ring, as in 1-nitro 2-naphthol. However, as the acid is converted to the anion, there is an increase in the size of the solvation shell around the hydroxyl-

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[5] The pKa values reported for *ortho-*, *meta*, and *para*-nitrophenols (7.23, 8.35, and 7.14 respectively), do agree very well with our experimental values.

[6] Hunsberger, I., et al. Jour. Amer. Chem. Soc. 80 (1958) 3295.

[7] Inductive effect.

TABLE 1.—*K_a and pK_a of some phenolic compounds.*

Compound	pK_a	K_ax10^{10}
ortho-Nitrophenol	7.20	631.0
meta-Nitrophenol	8.32	48.3
para-Nitrophenol	7.16	693.0
1-Nitro 2-naphthol	9.02	9.57
2-Nitro 1-naphthol	8.72	19.1
Phenol	9.95[a]	1.12
2-Naphthol	9.95[b]	1.18
1-Naphthol	9.85[b]	1.41

[a] Judson, C, and M. Kilpatrick. Jour. Am. Chem. Soc. 71 (1949) 3110.

[b] Schenkel, H. Experientia (1948) 383.

TABLE 2.—*Spectrophotometric data.*

Compound	conc. x 10^{-5} M	0.1 N HCl		0.1 N NaOH		Buffer		Buffer	
		mμ	O.D.	mμ	O.D.	mμ	O.D.	mμ	O.D.
						pH	7.20	pH	8.00
ortho-Nitrophenol	3.0	276	0.180	265	0.090	250	0.130	250	0.103
	4.0	276	0.240	265	0.120	260	0.172	250	0.134
	10.0	276	0.617	265	0.330	260	0.469	250	0.368
						pH	8.50	pH	8.00
meta-Nitrophenol	8.0	275	0.164	242	0.320	245	0.268	246	0.215
	9.0	275	0.217	242	0.460	245	0.356	246	0.295
	20.0	275	0.543	242	0.970	245	0.810	246	0.600
						pH	7.90	pH	8.00
para-Nitrophenol	6.0	320	0.587	284	0.090	257	0.159	275	0.158
	8.0	320	0.781	284	0.111	257	0.196	275	0.200
	10.0	320	1.00	284	0.120	257	0.135	275	0.243
						pH	9.50	pH	9.90
1-Nitro 2-naphthol	1.2	255	0.070	255	0.147	255	0.118	255	0.126
	1.6	255	0.080	255	0.167	255	0.143	255	0.160
	2.0	255	0.094	255	0.208	255	0.179	255	0.197
						pH	8.85	pH	9.10
2-Nitro 1-naphthol	2.0	250	0.234	237	0.139	237	0.180	237	0.160
	3.0	250	0.324	237	0.204	237	0.265	237	0.239
	4.0	250	0.399	237	0.290	237	0.340	237	0.320

TABLE 3.—*Determination of pK_a.*

Compound	pH	pK_a			Average pK_a	K_ax10^{10}
		1	2	3		
ortho-Nitrophenol	7.30	7.273	7.184	7.203	7.200 ± 0.034	631.0
	8.00	7.184	7.129	7.227		
meta-Nitrophenol	8.00	(8.812)	8.317	8.314	8.016 ± 0.023	48.3
	8.50	8.278	8.299	8.374		
para-Nitrophenol	7.90	7.192	7.062	7.118	7.159 ± 0.046	693.0
	8.00	7.199	7.182	7.202		
1-Nitro 2-naphthol	9.50	9.037	9.081	9.281	9.019 ± 0.097	9.57
	9.90	8.931	8.842	8.943		
2-Nitro 1-naphthol	8.85	8.731	8.864	8.782	8.720 ± 0.072	19.1
	9.10	8.551	8.715	8.677		

oxygen due to the presence of a charge in the anion. This solvation shell will be sterically hindered by the hydrogen attached to the 8-position in the case of 2-nitro 1-naphthol which therefore destabilizes the ionic products. Thus, the ratio of the K_a's of the nitro-derivatives should not be too far from that of the unsubstituted naphthols which is quite different from the experimental result.

The non-equivalent increase in acid strength in the isomeric nitro-naphthols is probably due to a more extensive hydrogen bonding in 1-nitro 2-naphthol than in 2-nitro 1-naphthol. An examination of molecular models (Fisher-Hirschfelder-Taylor models) shows steric interactions between the hydrogen attached to the 8-position of the naphthalene nucleus and the oxygens of the nitro-group when the latter is situated at the 1-position. This steric crowding shortens the gap that is bridged by the hydroxyl-hydrogen thus increasing the strength of the intramolecular hydrogen-bond in 1-nitro 2-naphthol, i. e., there is steric facilitation of chelation. Infrared studies [8] also suggest such an effect.

EXPERIMENTAL

PREPARATION OF COMPOUNDS SELECTED FOR STUDY

ortho-Nitrophenol: The compound was obtained from Eastman Kodak Co. and purified by recrystallization from water, m.p. 45°; reported [9]: 45°.

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[8] Hunsberger, loc. cit.

[9] Hodgman, C., ed. Handbook of Chemistry and Physics 31st ed. Chemical Rubber Publishing Co., Ohio, 1948.

metra-Nitrophenol: The compound was prepared by the diazotization of *meta*-nitroaniline.[10] 105 gm (0.75 mole) of *m*-nitroaniline and 53 gm of sodium nitrite gave 50 gm (0.36 mole; 59 per cent yield) of *m*-nitrophenol. Recrystallization from hot HCl gave a compound which melted at 97°, reported[11]: 96 to 97°.

para-Nitrophenol: The *p*-nitrophenol was obtained from Eastman Kodak Co. and recrystallized from water, m.p. 113.5°; reported[11]: 113 to 114°.

1-Nitro 2-naphthol[12]: 10 gm (0.03 mole) of 1-nitroso 2-naphthol was dissolved in 120 ml of water and 90 ml of conc. nitric acid was added with constant stirring. The mixture was left overnight at room temperature. The mixture was diluted with 200 ml of water, filtered and steam distilled. 40 gm (0.01 mole; 67 per cent yield) of 1-nitro 2-naphthol was collected, m.p. 104°; reported[13]: 103°.

2-Nitro 1-naphthol: 50 gm (0.17 mole) of *alpha*-naphthol[14] and 50 gm of anhydrous zinc chloride in 300 ml of alcohol was refluxed while an aqueous solution of sodium nitrite (50 gm) was added. The mixture was heated for two hours and left overnight. The precipitate was removed by suction filtration, washed with cold alcohol and suspended in water. Hydrochloric acid was added and the precipitate was filtered and washed with cold water. The precipitate is composed of the two isomers, 1-hydroxy 4-nitrosonaphthalene and 1-hydroxy 2-nitrosonophthalene. To separate them, 15 gm of potassium hydroxide in 150 ml ethanol was added. The mixture was left overnight and the undissolved potassium 2-nitroso 1-naphtholate was removed by filtration and washed with cold alcohol. The salt was dissolved in hot water and precipitated with hydrochloric acid. The crude product was recrystallized from water. 15 gm of the pure product melting at 163° (reported[15]: 162 to 164°) was obtained.

10 gm (0.03 mole) of the 2-nitroso 1-naphthol was dissolved in 120 ml of water. To it was added, 90 ml of conc. nitric acid

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[10] Clarke and Brethen in Organic Syntheses. 2nd ed., coll. vol. I, edited by Blatt. J. Wiley and Sons, New York, 1941.

[11] Lange, N., ed. Handbook of Chemistry 7th ed. Hondbook Publishers, Ohio, 1949.

[12] Adapted from E. Grandmogin and O. Michel, Ber. 25 (1892) 927.

[13] Lange, loc. cit.

[14] Adapted from Ilinski and Henriques, Ber. 18 (1885) 706.

[15] Lange, loc. cit.

with constant stirring. After standing overnight, the mixture was diluted with water, filtered and steam-distilled. 3.5 gm (0.01 mole; 59 per cent yield) of 2-nitro 1-naphthol was collected, m.p. 128°; reported[16]: 128°.

DETERMINTION OF PKa

The Beckman DU Spectrophotometer was checked according to the procedure of Ewing and Parsons.[17]

0.05 M solution of the compounds selected for study were prepared in each of the following solutions as solvent: 0.1 N HCl, 0.1 N NaOH and two buffer solns. of different pH.[18] The pH depends on the particular compound and must be near the pKa, preferably one below and one above it. The buffers used were KH_2PO_4–NaOH and H_3BO_3–KCl–NaOH mixtures. The three different concentrations for each compound involving the different solvents were prepared by successive dilutions to minimize concentration errors.

The spectra of the compounds from 220 to 350 mμ in the acid and base solutions using the three different concentrations were taken against a reference with the same composition except for the compounds. Conformity with Beer's law in the acid and base solutions were taken into consideration, i.e., plotting concentration versus the wavelength should produce a straight line. After conformity with Beer's law was established, the absorption curves of the various compounds in the buffer solutions were taken. The pH of the buffers were checked before and after each run. The more useful portions of the spectrophotometric data are summarized in Table 2. The pK_a's were calculated using the following equation:

$$pK_a = pH_{buffer} + \log \frac{A_{buffer} - A_{NaOH}}{A_{HCl} - A_{buffer}}$$

where A is the optical density of the soln. concerned. The results from calculations are summarized in Table 3.

ACKNOWLEDGMENT

We would like to express our appreciation to Dr. James G. Traynham of the Dept. of Chemistry, Louisiana State University, for his critical comments and valuable suggestions concerning this investigation.

[16] Lange, loc. cit.

[17] Ewing and Parsons, Anal. Chem. 20 (1948) 423.

[18] Lange, loc. cit.

JAR BURIAL IN THE BABUYAN AND BATANES ISLANDS AND IN CENTRAL PHILIPPINES, AND ITS RELATIONSHIP TO JAR BURIAL ELSEWHERE IN THE FAR EAST *

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TEN PLATES AND SIX TEXT FIGURES

INTRODUCTION

The prehistoric archaeology done in the Far East has been very uneven in its coverage of both area and time. For the most part the work has been done as sites came to the attention of the proper authorities, where such authorities existed. Previous to the second World War the only really systematic work done with a specific problem in mind was the research done on the Palaeolithic. The one other problem which did receive some attention, as far as the search for sites and excavation thereof is concerned, was that of the so called "jar-burial culture."

It is time that the question of jar burials is looked at critically, to examine an assumption that has been made, and to see whether it should continue to be used as a working assumption. This assumption is that the wide distribution of jar burials indicates a migration of people. Examination of this assumption and the presentation of new data is the primary purpose of this article.

Any one jar-burial site presents three varieties of information which are of use for comparative purposes: the jars themselves, their physical arrangement, and their associated artifacts. If the jars, in their form and disposition, and the associated artifacts, are reasonably consistent from site to site, or show a fairly consistent change in one direction in space, it would be a reasonable assumption that the people who had used the jars for burials and who had left other artifacts associated with those jars, were the same or closely related. On the other hand, if the comparison of a number of jar-burial sites shows considerable difference between the jars and their position and the associated artifacts, there are two possible explanations; either the people making use of the jars were not the same culturally, or the sites were from such different periods of time that the material culture had changed during the lapsed time. The latter possibility would be difficult to work out without accurately dated sites because over an area of any size, change in both space and time would be involved. By comparing jars, their position, and the associated artifacts from a number of sites it can be seen that the assumption of a single jar-burial culture is probably incorrect.

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* An expansion of a paper entitled "Comparative notes concerning burial jars in the Babuyan and Batanes Islands, Philippines" presented at the joint meeting of the Rocky Mountain and the Western States Divisions of the American Association for the Advancement of Science, held at the University of Arizona in April, 1957.

New data from the Babuyan and Batanes Islands, from Formosa, and from central Philippines will be presented along with summaries of the previously published information from the areas. No attempt will be made to cover all the published information; only that which is in hand will be used.

SITES BETWEEN LUZON AND FORMOSA

There has probably been more published material on burial jars found in the Babuyan and Batanes Islands than on any similar area in the Far East except India. These accounts have been both scientific and romantic and some of the conclusions are of no value. Within the subareas a summary of the published material will be presented followed by the new data.

ACKNOWLEDGMENTS

In June of 1952 my wife and I spent a week on Fuga Island in the Babuyans at the invitation of Mr. Alfonso Sycip and as the guests of Mr. Alfonso Lim. From Mr. Sycip in Manila I had first heard of the burial jars on this island and Mr. Sycip had been so kind as to show me a number of beads which had been collected from some of the jars. To both Mr. Sycip and Mr. Lim, who made arrangements for us on the island, we owe many thanks.

In April of 1953 I spent a week on Batan and Sabtang in the Batanes Islands, on business for the United States Information Agency. I was able to spend part of one afternoon and the next morning excavating a jar which had been found accidentally a few weeks before. I would like to thank Inez de Beauclair, of

Academia Sinica in Taiwan, for further information on burial jars in the Batanes Islands.

I would like to thank also the UNESCO office in Manila and its then director, Dr. Jan Smid, for sending animal bones to Dr. D. A. Hooijer in Leiden, Holland, for identification, and Dr. Hooijer for his identification. To Mrs. Kamer Aga Oglu I am indebted for information on a stoneware jar.

From Dr. Sung Wenshun, of the department of archaeology and anthropology of the National Taiwan University, I received information on jar-burial sites in Formosa and heard of a discovery of burial jars in Formosa which had not been published. I wrote to one of the discoverers, Professor Dr. Takeo Kanaseki, of Kyushu University, Japan, and from him received all the details and drawings that he could assemble on this site. I thank both of these gentlemen for their assistance.

Finally, from Dr. J. Edward Kidder, Jr., and from Mr. H. R. van Heekeren, I received information on jar-burial sites in Japan and Indonesia.

BABUYAN ISLANDS

The Babuyan Islands are a group of five small islands just north of Luzon; they are Camiguin, Dalupiri, Fuga, Calayan and Babuyan Claro (Fig. 1). Fuga is the closest island to Luzon. It is visible on the horizon on a clear day from the coast near Taggat, Ilocos Norte. From the north coast of Fuga the Island of Dalupiri is clearly visible, as is Camiguin from the eastern end of Fuga. Calayan is visible from Dalupiri and possibly also from Camiguin.

Jar-burial sites have been previously reported for all the Babuyan Islands with the possible exception of Fuga. The first published report of burial jars in the Philippines was on jars from Camiguin.(13) The only other detailed scientific report concerns Dalupiri.(1) A serious amateur archaelogist has reported on jars from Calayan(1) but I have not seen the original article. Beyer(3) reports that numerous jar burials were located on Babuyan Claro, though none have been excavated.

The physical surroundings of the burial jars appear to be similar on all the islands. They are usually situated in artificial cairns. Bartlett(1) reports that on Dalupiri "Each consisted of a circular enclosure from eight to fifteen feet in diameter, the wall being of rough coral rock, laid without any great care in fitting and without mortar, and originally about

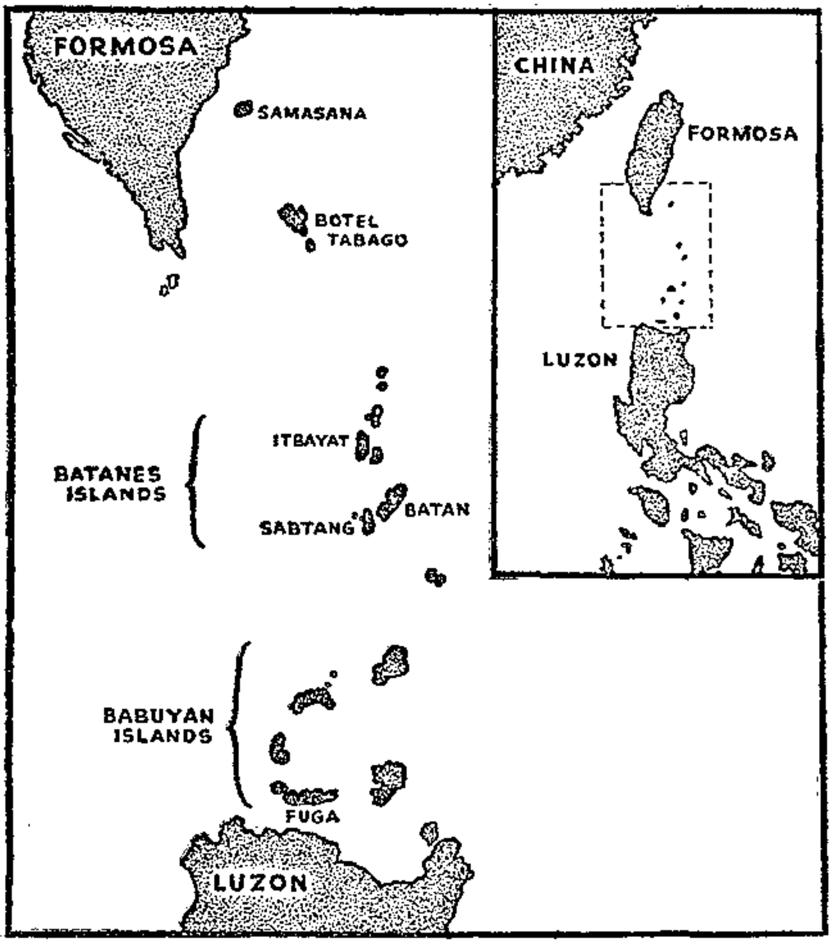

FIG. 1. Map of the Babuyan and Batanes Islands.

four feet high . . . In the center the jar was sunk about to the rim in the earth. At the time of burial a second inverted jar of the same sort fitted outside the rim of the lower one . . ." Nothing was found in the jars as those examined had been emptied earlier. Both large jars, big enough for primary burials, and smaller jars, large enough only for secondary burials, were seen. There were rumors that blue and white porcelains and dragon jars had been found, but when none could be located, Bartlett felt that this information was incorrect.

On Camiguin it is much the same with large or small jars in cairns with covers of inverted jars of the same or different shape as the base. The contents of these jars, besides a few bones, were a few pale-blue glass beads.(13)

The jars on Calayan were not only of earthenware but included at least one green glazed jar of late Tang or early Sung period. In some of these jars were found a few red carnelian beads, some pottery rings or ear-ornaments, but no metal.(3)

Previous to the excavations made in 1952, no archaeological work had been done on Fuga; in fact it was questioned whether jar-burial sites were present.(3) The work done in 1952 brought to light three different sites. At least one other site not investigated was known by the local inhabitants.

Two of the three sites (Sites 3 and 4) in which some excavation was done are near the north shore of Fuga, at the western end of the island opposite the barrio of Villa Vicenta. The third site (Site 5) is at the extreme eastern end of Fuga.

SITE 3

This site is made up of several scattered jars at about 30 meters elevation, three or four hundred meters from the coast. The jars are visible at the ground surface, with no mounds or cairns in evidence. The ground is made up of solid and fragmentary coral with a shallow layer of dirt between outcroppings. The jars were placed in shallow holes enlarged in the solid coral.

The earthenware jars, with one slight exception, were similar to those from the other two sites. All varied from tan to dark brown in surface color, with fire clouds. The paste was brown, zoned to a darker chocolate-brown in the center, was tempered with rounded light-colored sand, and had occasional small rounded pebbles. The inner surface of the jars showed, by small circular impressions, the probable use of an anvil in manufacture. On the outer surface were the small flattened surfaces and straight lines from a smooth paddle. The inner surface of the jars had been scraped and the outer surface, particularly near the rims, had in many cases been smoothed with some kind of fabric. The rims were straight or slightly everted (Fig. 2, *a* and *b*) and the bottoms were rounded or slightly pointed. Some jars had a red slip. Detailed measurements of the jars are given in Table 1.

Burial jar No. 1.—This jar differed slightly from the other burial jars observed in that 7 cm below and parallel to the edge of the rim was a ridge, 6 to 10 mm wide and 7 mm thick

(Fig. 2, *c*). This ridge showed no indication of having been applied, so either it was molded *in situ* from the clay of the vessel wall or it was appliqued in rough form before the surface of the jar was smoothed. In forming the ridge fingers were probably used holding some kind of fabric as the surfaces and angles are not flat, and show fine parallel lines. The jar was broken at the surface of the coral in which it was embedded and had pieces of its rim inside, including one sherd from a possible lid. Otherwise it was empty.

TABLE 1.—*Measurements of burial jars and lids.*

Jar	Height	Rim diam.	Max diam.	Thickness	Hardness	Bottom	Contents*
	cm	*cm*	*cm*	*mm*			
1	60	--------	51	18–21	4.0–4.5	pointed	--------
2	68	46	--------	15–19	4.5–5.0	--------	1,2
2a	63	--------	--------	7–10	--------	flat	lid
4	45	ca10	34.5	9–11	stoneware	flat	bead
6	53	36	ca40	10–17	4.0–4.5	rounded	2
6a	61	ca45	56	10–18	4.5	rounded	lid
7	--------	--------	--------	7–14	5.0–5.5	rounded	beads
7a	--------	--------	--------	13–15	4.0	rounded	lid
12	ca40 ca40	--------	39	6–10	stoneware	flat	2

* In "contents" column: 1, metal ring; and 2, stone or shell disk.

Burial jar No. 2.—The second jar was 7 meters west of the first. Except for the ridge and a slightly out-turned lip it was of the same shape as the first. The rim was at the level of the coral and on top of it had been a bowl, placed as a lid. This broken bowl probably had a flattened bottom but there was no angle between the side and the bottom. In making this flat bottom the potter had made it too thin in one area. To strengthen this area a lump of clay had been added on the inside and had been joined by pressing back and forth across its surface with a smooth rounded tool as indicated by short striations, 1 to 3 mm wide, in the area of the addition. The bottom, generally 7 to 10 mm thick, was 29 mm thick at its heaviest point.

Inside the jar were a few fragmentary bones, two pieces of metal, and a shell disk (Plate 3, *a* and *c*). The disk was 35 mm in diameter, 11 mm thick and had beveled edges. The pieces of metal were one complete and one fragmentary ring. The complete ring was made from a wire 3 to 4 mm in diameter, and was 27 mm long by 20 mm wide. Like the other relatively complete rings found in other jars, it was not formed in a true circle but had one flattened side (Plate 3, *a* to *c*). The fragment was of a finer wire, 1.5 to 2 mm in diameter. A spectroscopic analysis of the complete ring, made by the Arizona Bureau of Mines, indicated that the metal was primarily copper with a little tin, some silver, but no zinc. The ring was very heavily corroded with little of the original metal left.

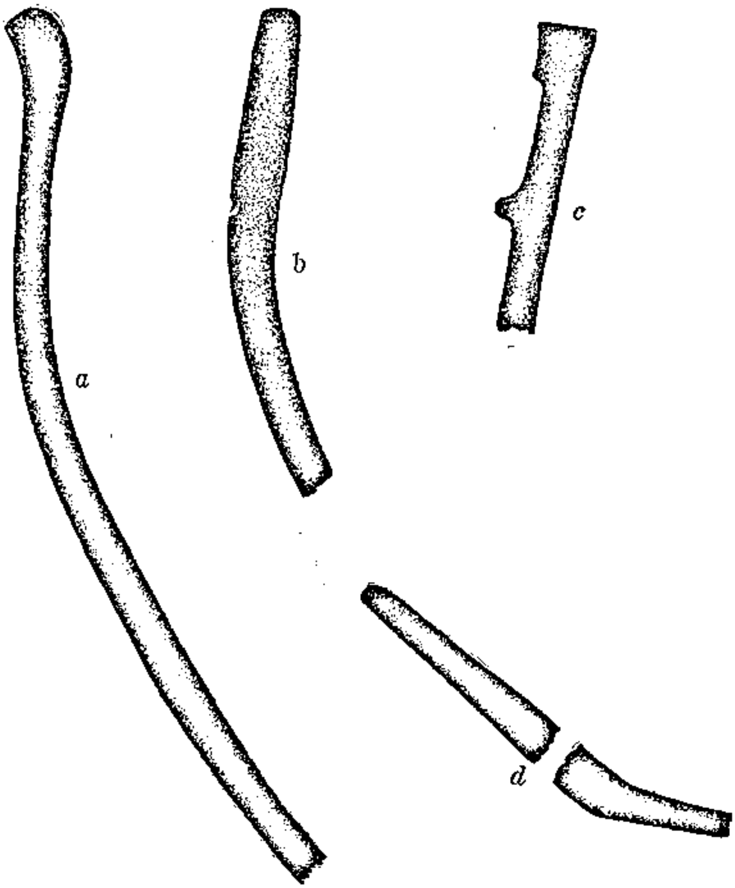

Fig. 2. Cross sections of burial jars and lids from Fuga Island.

Burial jar No. 3.—Similar in shape and size to jar No. 2, this empty jar was on a coral promontory about 20 meters west of No. 2. Other jars in the area in similar condition and shape were not examined. None of these jars were large enough to have contained primary adult burials.

SITE 4

Site 4 was on a rolling plateau about 100 meters east of Site 3 and about 50 meters higher. This difference in altitude is abrupt in the form of an eroding bluff. There was much less coral near the surface in this area than at Site 3. The tops of broken jars can be seen over a wide area protruding slightly from the dirt in the short bunch grass cover. This cemetery ends on the north at the cliff-edge above the sea. Here erosion has started cutting away into the edge of the cemetery. From this eroding side seven jars were excavated, some of them quite incomplete (Plate 1, *a* and Fig. 3). From the jars excavated and the ones whose tops could be seen, there was no apparent order of placement.

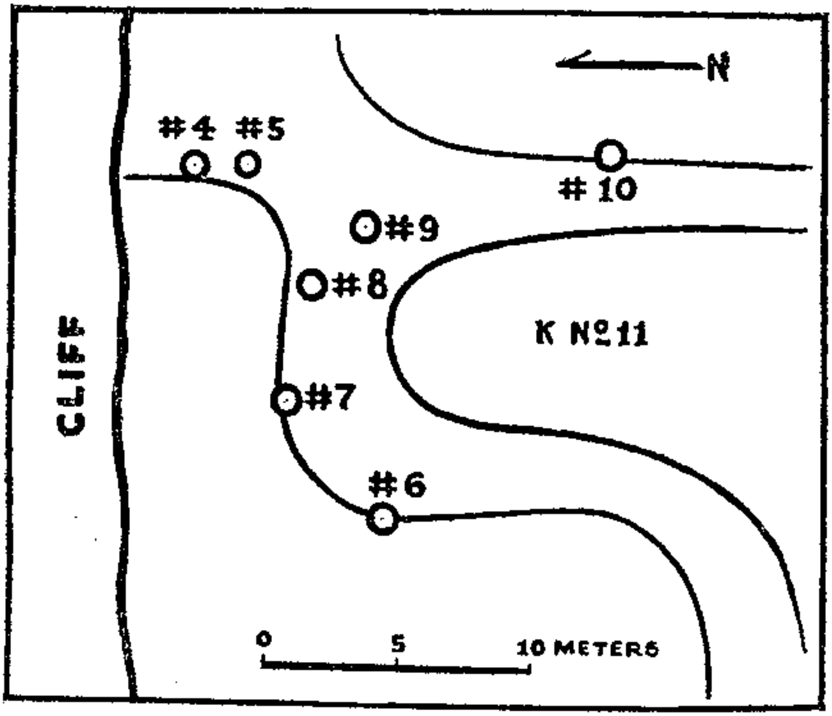

FIG. 3. Sketch map of site 4, Fuga Island.

Burial jar No. 4.—This was the most unusual jar of those excavated on Fuga. It was a plain stoneware jar with an olive-brown glaze. Its slightly concave base was 16.8 cm in diameter. From this base it increased evenly in diameter to a maximum diameter at the shoulder of 34.5 cm, at a height of 31.5 cm above the base. Above the shoulder it was rounded, decreasing to a small mouth about 10 cm in diameter, with a neck and rim 2.5 cm above the shoulder. The lip of the rim increased slightly in thickness. Around the neck were four or more small applique loop handles. The neck and rim had been purposefully broken from the jar.

Inside the jar were animal bones, a bead, and a small piece of iron. The iron fragment was roughly rectangular in cross section with a head like a nail. The bead was doughnut shaped, 4 mm thick and 6 mm in diameter. It was made of light blue, opaque glass.

Dr. Hooijor's identification of the bones was as follows: "*Suncus murinus* (L.) subsp. (Oriental house musk shrew, an insectivore frequently found about human settlements): skull." One human tooth. "*Ovis aries* L. subsp. c.g. *Capra hircus* L. subsp. (domestic sheep or goat) . . . Apparently two individuals, most of the remains belonged to a subadult animal." The bones of the two goats (?) about filled the jar, and must have been placed therein as they were not articulated.

Burial jar No. 5.—In very fragmentary condition, this earthenware jar was without accompanying materials.

Burial jar No. 6.—The best-preserved of any of the undisturbed jars (Plate 1) this earthenware jar had a large lid and contained a complete skeleton and one artifact. No coral was in the dirt in the immediate vicinity of the jar and no mound or other marking was in evidence above the jar. The lid was larger than, but of essentially the same shape as, the bottom jar, and overlapped it about 30 cm (Fig. 2, *a* and *b*). For the two to have been in this relative position the bottom jar was probably first placed upright in a prepared hole and some dirt added to hold it in position. When the lid was added the dirt around the bottom of the first jar prevented the top jar from overlapping to its maximum possible extent.

The bottom jar had been made in two stages. The lower part, 24 cm high, was made first and then probably allowed to dry sufficiently to hold the weight of the top part without warping. The edge of the lower section was triangular in cross section. The top, when it was completed, thus had a triangular cross-sectioned canal for its edge where it joined the lower part.

Inside the jar was a primary burial of an adult human. On drying without preservative the bones largely disintegrated. The one incisor tooth observed was shovel-shaped. The only artifact in the jar was a very smooth, fine-grained, stone disk, 3 cm in diameter and 13 to 15 mm thick. The stone was a natural waterworn disk, but nearly circular (Plate 3, *e*).

Burial jar No. 7.—This jar was similar to No. 6, with an earthenware-jar lid overlapping the lower jar by 21 cm. The bottom jar had a fugitive red slip and a slightly everted lip.

The bones in the jar were in such poor condition that it was impossible to tell the type of burial, though the jars were large enough for a primary burial. The four incisors were all shovel-shaped. In one humerus, the olecranon fossa had not closed, although it was evident from the teeth, which were heavily worn and fully erupted, that the individual was an adult.

There were a large number of beads present. There was one rough biconical carnelian bead with the hole, 2 mm in diameter, drilled from one end with a cylindrical drill. This bead was 15 mm long and 11 mm in greatest diameter. There were 14 heavily patinated, opaque glass beads. Three were dark blue, doughnut-shaped, 4 mm thick, 6 mm in diameter, with the hole 2 mm in diameter. Ten were light blue-green of the same size and shape. One light blue-green bead was cylindrical, 4 by 4 mm, with a 2 mm diameter hole. About 75 smaller beads, 2 to 4 mm in diameter, were so heavily patinated that their color and composition could not be determined. There were about 200 larger, vitrified, orange paste-beads, doughnut-shaped, 3 to 7 mm in diameter and 2 to 5 mm thick.

Burial jar No. 8.—Similar to the last two burial jars, these two jars differed only in that the top jar had a small flat bottom, rounded to the sides. Inside, besides the very fragmentary bones, were several beads like those in burial jar No. 7. There was one cylindrical light-blue glass bead, one doughnut-shaped dark-blue glass bead, and 20 doughnut-shaped, vitrified, orang paste-beads.

Burial jar No. 9.—The jars of this burial were fragmentary and somewhat different from the others. The bottom jar had been polished inside using a smooth-surfaced tool. Over the fabric marks on the outer surface of the out-turned rim were some polishing striations extending a centimeter or two down the side. The lid was somewhat heavier than the bottom and had a fugitive red slip on both surfaces. It was bowl-like in shape with an angle between the side and bottom (Fig. 2, *d*). Both surfaces had been smoothed before slipping.

Associated with this jar, possibly inside, was a small stoneware jar with an olive-brown glaze, narrow neck and small loop handles. In the Philippines this variety is called a "Gusi" jar. The few sherds of this jar recovered could not be identified by Mrs. Aga Oglu, but she felt that it was probably not Chinese but from further south. These sherds are now at the Anthropology Museum of the University of Michigan.

Burial jar No. 10.—Only the bottom of this jar and a portion of its contents were remaining. Three incisors present were all shovel-shaped. There were a few fragments of porcelain in the jar but they were so small that they could not be identified.

Two bronze rings present were of the same shape as the one from burial jar No. 2. One of these was plain, 25 mm long by 19 mm wide, made from wire 3 mm in diameter. The other had a single fold at one end and a double fold at the other (Plate 3, *a* and *b*). It was 29 mm long by 22 mm wide, and made from wire the same size as the first.

SITE 5

Site 5 covers several acres along the shore on the eastern end of Fuga. It extends from practically the shore line, at a meter or two above the level of high tide, inland for 30 to 70 meters on the slightly sloping shore. This site has been well explored by the inhabitants of the islands and no undisturbed jars were located. A large collection of carnelian and other types of stone, glass, and paste beads had been made by Mr. Sycip from various jars in this site, but as their provenience was not known they were not carefully examined.

The major difference between this site and sites 3 and 4 was that here each jar had been placed in a coral cairn one to two meters high. Another difference was that several of the burial jars were of glazed stoneware, though they still had earthenware jars as covers.

Burial jar No. 11.—This jar was similar to burial jar No. 9 except it was without smoothing and polishing. The lid was a red-slipped jar with a flat bottom, on the outer surface of which was the imprint of a large leaf. Between the bottom and the sloping sides was a distinct angle. The only remaining contents, besides a few bone fragments, were a large number of small seashell opercula from 1 to 3 cm in diameter.

Burial jar No. 12.—This stoneware jar was roughly spherical with a small flat bottom and an angle between the side and shoulder (Plate 2, *b*). Inside there remained two small worked stones and one piece of worked shell (Plate 3, *f* to *h*). The shell was roughly oval, 30 by 23 mm and 10 mm thick. One of the stones was a fine-grained water-worn pebble, broken off at one end making it roughly circular, about 25 mm in diameter and 10 mm thick. The other was a fine, sandstone disk, ground to a circular shape and with beveled edges. It was 25 to 27 mm in diameter and 13 mm thick.

Other remains.—The two jars above were the only ones found with any remaining contents. One complete earthenware jar and two large, glazed stoneware jars were brought back to Manila. The earthenware jar (Plate 2, *a* and *c*) is in the Philippine National Museum and the two repaired stoneware jars are in Professor Beyer's possession at the Museum and Institute of Archaeology and Ethnology in Manila. The other materials collected are in the Arizona State Museum in Tucson, Arizona. Both of the stoneware jars had been purposefully broken slightly above the angle of the shoulder presumably to enlarge the opening (Plate 4, *b*). Beyer could not definitely identify these jars, but felt that they came from South China or Indo-China and probably were from late Tang or early Sung times.(17)

Summary.—Burial jars of two general varieties and in two kinds of sites have been reported from the Babuyan Islands. Large earthenware jars with primary burials have similar jars or flat-bottomed bowls for lids. Large or small glazed stoneware jars have earthenware lids similar to those for the earthenware jars. The larger jars could have contained primary burials while the smaller jars could only contain secondary burials. No evidence of cremations was noted. The jars were found buried in the ground or in coral with no indications of a surface monument, or were in coral cairns above the surface.

The associated artifacts were specifically noted only from jars on Fuga, although glass and stone beads and pottery rings were mentioned as coming from some of the jars on other islands. Besides beads, the jars on Fuga contained metal rings and circular pieces of stone or shell. The circular artifacts were found in both earthenware and stoneware jars while the metal rings came from earthenware jars. However, a few unidentifiable sherds of porcelain were associated with the rings in one of these jars. The rings and circular artifacts were found together or separately.

Conclusions.—From this general and very incomplete information, plus the nearness of the islands, it is a fair assumption that the Babuyan Islands were inhabited by a related group of people following the custom of jar burial.

The variation present in the kind and size of the jars and in the sites could well be due to local evolution and specialization over a period of time. The apparently large numbers of jars present in Site 4 on Fuga and some of the sites on the other islands also would indicate that the practice was in use for some length of time. These islands could hardly have supported a population large and wealthy enough to have accumulated the large number of jars within a hundred years or less.

Without further identification of the stoneware jars it can only be said that they apparently came from South China or Indo-China possibly in Tang or Sung times. The custom of burial in jars could have been in use for a long time previous to this and could have lasted long after.

BATANES ISLANDS

The major islands of Batan, Sabtang, and Itbayat lie north of the Babuyan Islands, roughly half way between them and Formosa (Fig. 1). From Batan it is only a few miles to Sabtang; and Itbayat, the largest of the islands, is in sight to the north on a clear day.

Beyer(3) states that several jar-burials have been located and explored on Batan. These were located in mounds, locally known as *padapaday*. "The jar containing the body was usually first put into an excavation—sufficiently deep so that the top of the cover was seldom much above the ground level—and then the hole was filled in and covered with an earthen round of some size . . . but no stone cairn." The jars were of thick half-baked pottery or stoneware.

Manuel(12) has noted that the custom of jar burial may have lasted into historical times in the Batanes Islands. From a report written by Don Joaquin Melgarejo, who lived with the people of the Batanes for five months in 1770, it would seem that jar burial was still in practice at that time. The burial vessel of one burial that he had witnessed was not specifically described. However he likened it to an "oven" which was placed into a hole in the ground. After putting this empty "oven" in the hole the body was slipped in. As Melgarejo probably would have noted if a glazed stoneware jar were used, in which case he would not have compared it to an oven, it would seem possible that the jar he saw was earthenware.

Some points of interest concerning this burial were that the ear pendents, personal jewelry and other precious objects were removed from the body, and all that was interred with him were his other belongings, such as plates, jars, and oars. The burial was made in the dead man's field, and apparently not in a cemetery. Fifteen days after the burial a kid was sacrificed, cut up, and taken to the location of the grave where a ceremony, which was not described, was held.

A jar burial site on Batan.—The site, with one jar, was located in a camote field on a hillside west of Basco, the capital of Batan. Although at an elevation of about 40 meters, it was not in sight of the sea as it was on a slope facing inland, about 500 meters from the sea. The individuals who had discovered the jar had broken into the covering jar, emptied it and the lower jar of their contents, and then filled the jars again with dirt.

Both jars had been buried below the sloping surface of the ground with the bottom of the upper jar about 20 to 30 cm below the surface. The general slope of the hill was about 30 degrees, but at this point a small area had a slope of about 10 to 15 degrees.

Though the bottom of the upper jar was missing, the rather sharp curvature of the wall where it was broken indicated that it had probably been flat and about 30 cm in diameter. From the bottom the jar flared to a maximum diameter of 56 cm at a height of 40 cm from the bottom. There was then a sharply incurving shoulder with a flaring rim 5 cm wide. The rim diameter was about the same as that of the base. The total height of this jar was 67 cm and the thickness of its wall from 7 to 15 mm.

The juncture of these two jars was unique in that the top jar rested with its shoulder supported by the rim of the lower jar and with its mouth and rim inside the mouth of the lower jar.

The bottom jar had been broken when it was first emptied and further broken in refilling when large stones were dropped into it before the filling with dirt. It had a rounded bottom, an inside depth of about 46 cm, and a maximum diameter of about 51 cm with the wall curving in slightly for the upper 8 to 10 cm. Pieces of both jars were left with the provincial governor to be shipped at a later date to the National Museum.

All that remained inside the jar were a few fragments of bone and teeth, including one shovel-shaped incisor. The reports were that the original finders had found nothing besides the bones, but it could well have been that they did not wish to report the contents for fear the provincial governor would have had them turn them over for deposit in the National Museum.

Outside the jars at the level of their juncture were three primary flexed burials (Plate 5). The first skeleton lay on its right side to the southeast of the jars with its skull about 8 cm away. Its body lay to the east with the skull at an angle to the body, the face looking west towards skeleton number three; an unnatural position. The hands were at the face with the figures on the cheeks or over the mouth. One incisor retained from this skull was shovel-shaped.

The second skeleton was to the north of the jars with the skull about 35 cm from the jar. The body was on its right side, etxending to the west, with the face looking north, away from the jars. Again, the hands were at the face.

The third skeleton lay to the south of the jars, with the body on its right side, flexed to the west and parallel to the second. The skull was about 30 cm from the jars with the knees and elbows somewhat closer. The skull was facing down and slightly towards skeleton number one, with the hands again at the face.

The sex of the first skeleton could not be determined, the second was probably female, and the third was a male.

On Sabtang, burial jars are common knowledge among the inhabitants. When they find a burial by accident they usually dig it up in hopes of treasure, though no indication of what the treasure might be was ever given. If the jar, or jars, are earthenware and unbroken they are saved for storage jars. Numerous jars of this nature are to be seen on Sabtang (Plate 4, *a*). When a decorated stoneware jar is found, it is immediately broken and the pieces thrown away. The same is done with porcelain bowls and plates when they are found as they fear that unfriendly spirits are attached to the vessels as long as they are whole. One glazed but otherwise undecorated stoneware jar, similar to the two from Fuga, was being used in Basco for water storage.

Several items of archaeological interest were noted on Sabtang which may or may not have been connected with the people who used the jars for coffins. In the town of Sabtang, opposite Batan, a large bedrock metate is still in use today for grinding. In the same town a jar with a high narrow neck was noted (Plate 6, *a*). According to the owner, this jar had been associated with a jar burial. It was of interest that the wife of the man who had located the jar, a potter, had made a jar in imitation of the prehistoric jar (Plate 6, *a*). The prehistoric jar was polished over a red slip. The new, and much heavier jar had a thick and crazed unpolished red slip. The neck of this jar has a polish from use. This shows how a particular pottery shape could spread over a larger gap in time, though it so happened that no further jars were made. The copy was not nearly as well made as the original.

Mrs. Inez de Beauclair, of Academia Sinica in Taiwan, recently spent several months in the Batanes Islands. From her we have the following notes on jar burials: on Itbayat cairns, jars were used only for children and valuables. In these cairns Beauclair found bones of several people. Locally, they are said to be from the "fightings." Some of the cairns had two headstones, and were said to be of the leaders. They are called *parapag*. On Sabtang new burial jars have been found. Also from the Beauclair was shown "a kind of stone cist grave. I assume that they all had several kinds of burials." On Batan two sites were located—one found in road-building and the other discovered on the south coast after a typhoon had washed off the earth from a burial site. "Also on Batan, on the western slope of the Iraya, was an interesting site, stones in an oval, encircling the graves." Beauclair hopes to be publishing more on this soon.(2)

Conclusions.—Obviously there is not enough information on the jar-burial complex in the Batanes to be able to say that the Babuyan and Batanes Islands were inhabited by people of a "jar-burial culture." In fact the several specific differences would indicate considerable variation at least. However, this may be due to the time element with culture drift in isolated locations.

The difficulty caused by change or lack of change in time is apparent. Beyer(3) says that the jar-burial culture on the

Batanes explored by Montenegro ". . . is perhaps the oldest jar-burial type in the Philippines—going back to the early centuries of the Christian Era." Yet it might still have been in practice in 1770. Possibly, in the case of a poor individual, a late burial might be in an earthenware jar without accompanying porcelain or stoneware to distinguish it from an early burial. This could occur as well in the Babuyans where earthenware jars were used for covers of stoneware jars. There is no reason why both top and bottom jars could not have been earthenware, used at the same time as stoneware was used.

The sacrifice of a kid at the burial witnessed in 1770 probably explains the presence of goat or sheep bones in the stoneware jar on Fuga and would probably indicate some close similarities in the burial ceremonies of relatively recent date between the two groups of Islands.

THE CENTRAL PHILIPPINES

No attempt will be made to give complete coverage to the jar-burial sites and finds known in the Philippines. Those known previous to 1948 can be found in Beyer's "Outline Review of Philippine Archaeology."(3) Further, there will be a summary review of the jar-burial question, including the important Philippine material, appearing shortly in the Proceedings of the 4th Far-Eastern Prehistory Congress. New data on two sites in Southern Luzon will be presented and these compared to two other subsurface sites and two areas of cave sites.

The San Narciso jar-burial sites.—San Narciso is a municipality on the east coast of the Bondoc Peninsula which juts out on the southern extension of Luzon. It is separated from the Bicol region of Luzon to the east by Ragay Gulf. The two sites to be covered are in the barrio of Punta, which is to the east of San Narciso on a small peninsula extending into Ragay Gulf. The two sites are at Recudo and Tumagudtud. This will not be a complete site report as the data necessary are not at hand. The materials excavated are at present in the Museum and Institute of Archaeology and Ethnology in Manila. At hand are a few unpublished pictures, field notes, and the preliminary published report, which will be referred to hereafter.

Recudo site.—From this site a total of six jar-burials were excavated with a minimum of accompanying material. The jars were of two varieties, a large one for primary burials and a smaller one for secondary burials and possibly for infant burials.(16)

The average size for the larger jar is: rim diameter 50 cm, height of rim from shoulder 25 cm, total height 75 cm, wall thickness 1 cm. Most of the large jars have a high straight neck and all have a rounded bottom with a cylindrical body and a narrow rounded shoulder. The smaller jars have a globular body with the following average measurements: rim diameter 25 cm, a straight neck 9 cm high, greatest diameter 40 cm, total height 45 cm, wall thickness 1 cm.

Besides the skeletal remains, each jar had either an iron point or points, or a few beads and possibly a glass bracelet. One small jar containing an infant burial had several beads. One of the large jar had some shell-bone artifacts as well as two iron points (Plate 7, *a*).(16) All the jars, at one time, had stone covers made from a coral limestone. The cover for the jar with the shell-and-bone artifacts was unusually large, requiring five men to lift it off the jar. It had a circle cut into it to fit the top of the jar. One of the jars had a few sherds from a small pot associated with it, but not enough to determine its shape.

Tumagudtud site.—Between the Recudo site and the village of Punta, on the edge of the barrio school property, was another group of jars, this one in the locality called Tumagudtud. The area excavated, besides containing 13 jar burials, had three non-jar burials and was on the edge of a living site. The same two kinds of jars were present in this site as at Recudo, but the stone lids were better made (Plate 7, *b*) and there was much more accompanying material.

This site was clearly stratified, with a top layer of black humus containing few sherds and shells, a gray occupation layer with many shells and a large number of sherds, and below that, sterile yellow coral sand. On the shoreward side of the excavation these layers were very even, but inland the gray level had an uneven bottom, as can be seen in the wall to the right and the rear in (Plate 6, *c*) and on this side it was much thicker than on the other.

At the top of the gray layer was found a secondary burial with no associated artifacts (Plate 7, *e*). The skull of this burial extended into the black layer above. In making the hole for the bones one of the burial jars was partially destroyed.

Therefore it can be assumed that this was an intrusive burial, placed there probably by coincidence.

The inhabitants of Punta were most surprised about the burials and said that they knew nothing about them. They said that according to their ancestors, the Punta burial had been in the San Narciso cemetery since the Spanish came, soon after the discovery of the Philippines. Some were buried in the forest during the revolution and the American occupation. However, these would not have been secondary burials, therefore this one is probably pre-Spanish.

Most of the burials, both in and out of jars had two to four small pots associated with them (Plate 7, *d* and *f*). These pots were usually found outside the jar, but in one instance where the jar was broken, pots were found inside the jar. These pots probably fell into the jar when it collapsed, as large sherds from the neck of the jar were found in the body of the jar below the pots.

Deep in the gray layer and apparently belonging to that layer were two extended burials (Plate 7, *b–d* and *f*) "Burial 17 (Plate 6, *d*) . . . was lying supine, fully extended with arms extended and hands under pelvis. Unfortunately, the skull and left shoulder and arm were largely destroyed by the workers in the first digging. The skeleton measured 129.5 cm from calcaneus to atlas so the individual was quite short. The form of the pelvis suggested that it was a male. Along the right forearm was the blade of a large knife or bolo with the point towards the feet. There were one or two small bowls of very thin and fragile pottery at the right side of the head and a piece of some kind of slag by the left tibia. (Several pieces of this slag were found in other parts of the site.)

"Burial number 23 (Plate 7, *f*) was a child of about seven or eight years lying supine and extended with hands under the pelvis. The head was to the northeast, just the opposite of burial number 17 . . . The child had a group of large cowry shells by its left knee, part of an angle pot by the head of the left femur and five shell bracelets around the right fore arm."(16) The bones from the left leg were missing as were the right foot and distal ends of the tibia and fibula. As the other extended burial was somewhat lower and the feet were very close to those of the child, it was probably buried at a later date than the child, cutting off the missing extremeties when its pit was dug. A few centimeters below the child's legs and associated with one or the other of the two burials was a small slender jar with one handle and a high straight neck (Plate 7, *f* and 8, *a*). This jar was 23 cm long and had a short applique ring stand. Unfortunately this jar was lost in transit to Manila.

All of the burial jars except one were badly broken (Plate 8, *c*). The unbroken one was the largest, with the most interesting contents. Beside the jar, as can be seen in Plate 7, *c*, were four small pots. Inside the jar, mixed with the dirt and bones were a large number of minute red paste-beads, less than a half millimeter in diameter. In addition to two stone tools, there were three skulls with mandibles.(16)

The bottom of the jar, below the level of the skulls, had not been cleared out when I left Manila, so whether the three skulls were accompanied by three complete skeletons is not known.

After clearing out the dirt, the skeleton in one of the jars showed clearly that the burials had been primary (Plate 8, *a*). As the flesh decayed the upper portion of the body fell forward leaving the skull face down. The arms and legs were doubled up on either side of the skull. The scapulæ were still in position but the ribs and vertebral column were somewhat disarranged.

From several of the jars came tanged spear points of various shapes and sizes (Plate 8, *d*). In other jars were found varying quantities of paste and glass beads and fragments of shell or glass bracelets. Inside one jar were found ". . . four good spear points of various sizes and a perfectly round shell disk about 12 cm in diameter and 1 cm thick."(16) This disk was perforated in the center.

In Plate 7, *b* and *c*, and Plate 9, *h* can be seen the most common shape for the small pots accompanying the jars. They had globular bodies with rounded bottoms, a wide mouth and a short everted rim. The next most common variety consists of jars with a high and rather narrow neck, an everted rim, and a flat shoulder at the base of the neck (Plate 9, *c*, *d*, *f*, and *g*). Jars *d*, *e*, and *f* show vertical marks on the neck made in smoothing the neck. Jar *e* (Plate 9) was incised in a band around the shoulder using a blunt-pointed two-pronged tool, with pairs of vertical marks below pairs of horizontal ones. Jars *a* and *b* (Plate 9), unlike the others, were not directly associated with any jar, though they may have been with one of the more badly damaged jars. Both had a bright red slip, as did one of the burial jars. The slip was soluble in water. Jar *a* was polished over the slip. Both had short perforated applique ring stands which were not slipped, and jar *a* had an applique spout. A nonslipped applique spout was found in the gray layer, but the vessel of which it had been a part was not located. The approximate size of these jars varied from about 13 to 26 cm in maximum diameter and the same in total height.

Many sherds were found in the gray layer. Some of them were incised and several showed impressions from a paddle carved with parallel grooves. A detailed analysis of this material has not been made.

Summary.—For other than the burial jars themselves there is very little that is distinctive about the pottery. There is not enough information to make any type descriptions. Using the few jars here described and pictured, six varieties can be distinguished on the primary basis of form and size. The two different sizes and shapes of burial jars (large and small) were briefly described for the Recudo site. In the Tumagudtud site these forms hold true, serving in both a different function, one for primary burials, the other for secondary or infant burials. Among the small vessel forms there are the globular-bodied pots with the short everted rim; the jars with short perforated ring stands, the jars having a variety of shapes, with spouts and handles, and some of them, red-slipped; the most distinctive group with the high necks, everted rims, and a flat shoulder at the base of the rim; and finally the one incised jar with a high outwardly curving neck and rim and with the band of incisions around the jar on the rounded shoulder. Detailed examination of the sherds from the occupation layer may show other types. The paddle-impressed sherds appeared to be from vessels that had been incompletely smoothed with a plane-surfaced paddle after the use of the curved paddle, so the impressions probably were from one of the stages of manufacture rather than a purposeful alteration of the surface for a decorative effect.

OTHER SITES IN CENTRAL PHILIPPINES

Described herein for comparative purposes are the subsurface sites in Samar and Masbate, and the two areas of cave sites on the east coast of Sorsogon in southern Luzon and in the nearby island of Cagraray in Albay Province.

Subsurface jar-burial sites.—The two sites in Samar and Masbate share the following specific items with the two San Narciso sites: (*1*) they are in sight of the sea; (*2*) none have a surface mound or cairn; (*3*) some jars contain small paste and/or glass beads of several colors; and (*4*) jar covers are of worked stone, often with a circular canal carved to fit the rim of the jar. Here their specific resemblances cease.

The site in Samar had several adult, supine, extended burials, some with iron weapons. The jars all contained very young children and were probably primary burials. There were no associated small vessels.(6)

In Masbate no trace of bone or teeth remained in the jars, but their size would indicate both primary and secondary burials. Two of the jars contained stone tools. Each jar had inside it two to four small pots which were not similar to those from the Tumagudtud site in Tayabas.(18) Fragments of blue glass bracelets were found in the immediate area of the site.

Except for those of the two Tayabas sites, the burial jars themselves differed in shape, though roughly similar.

Cave sites.—There are two distinct types of jar burials found in caves in Albay and Sorsogon Provinces, representing two distinct periods. In both varieties the jars were apparently left on the surface or placed on ledges and there were no stone covers. The earlier sites contained no iron, but stone tools were present. The later sites contain, besides the burial jars, porcelain of the 15th to 16th centuries.

"This jar-burial stone-tool assemblage has now been found in eleven different sites at Mataas and Misibis, Cagraray Island, and at Bato, Sorsogon, all of which yielded an identical type and range as associated materials—blue-green beads of an indurated shale, beads made of other hard stones or of the shell of the giant clam (*Tridacna* sp.), spoons made from the chambered nautilus, scoops made of cone shells, dippers made of "Bailer Shell' (Melo diadema) knives made of a large flake struck from a core, bracelets made from the top of large cones, and a plain undecorated pottery with high flaring necks and with approximately the same percentage of angle and slipped ware. The decorated ware, representing only a small percentage of the pottery, appears to be related to the Kalanay pottery found by Wilhelm Solheim II and Alfredo Evangelista in Masbate."(15) The burial jars of the Bato Caves, with a sharply angled shoulder and a high flaring rim, are distinct from those of the subsurface sites.

The proto-historic sites contained ". . . earthenware burial jars, Chinese porcelain and stoneware fragments, and iron and glass beads . . . Among the human remains recovered . . . were incisor teeth which had been filed (chipped) to a sharp point. No evidence of this practice was found in the jar-burial stone-tool assemblage. . . . The burial jars are smaller . . . and the forms are very distinct from those encountered in the jar-burial stone-tool assemblage."(5)

Summary.—In central Philippines there are two distinct types of jar-burial sites, each type with distinct varieties.

At the eastern edge of this territory, in Albay and Sorsogon Provinces, jar-burial sites have been found in caves. The two distinct varieties of this type of site may well owe their great differences to change in time. The early sites have the jars associated with stone tools, shell artifacts, and no metal. The late sites have a different form and size of burial jar associated with porcelain, stoneware, iron and glass. Intermediate sites have not as yet been found.

More central to this territory, the excavated sites are all subsurface, in the open. The jars from the different sites are similar in shape, and most are found with stone covers, but the associated artifacts, particularly the small pottery vessels, show little resemblance between one site and the next. All these sites probably fall within the time span of the Early Iron-Age with metal and/or a few pieces of early glass but no porcelain or stoneware.

It is doubtful that the great variety of the pottery, or lack of it, associated with the jar burials in central Philippines can be due to culture change in space or time of one closely related culture. The great differences between the early sites of the Bato Caves and the Early Iron-Age subsurface sites are further indications that one culture alone is not involved.

FORMOSA

The information on burial jars excavated in Formosa is slight. They have been found only on the eastern side of the island and on the outlying islands of Samasana and Botel-Tobago to the east and south.

From Botel-Tobago, Kano(9) has stated that "In the summer of 1935, a strange earthenware vessel was found at a certain

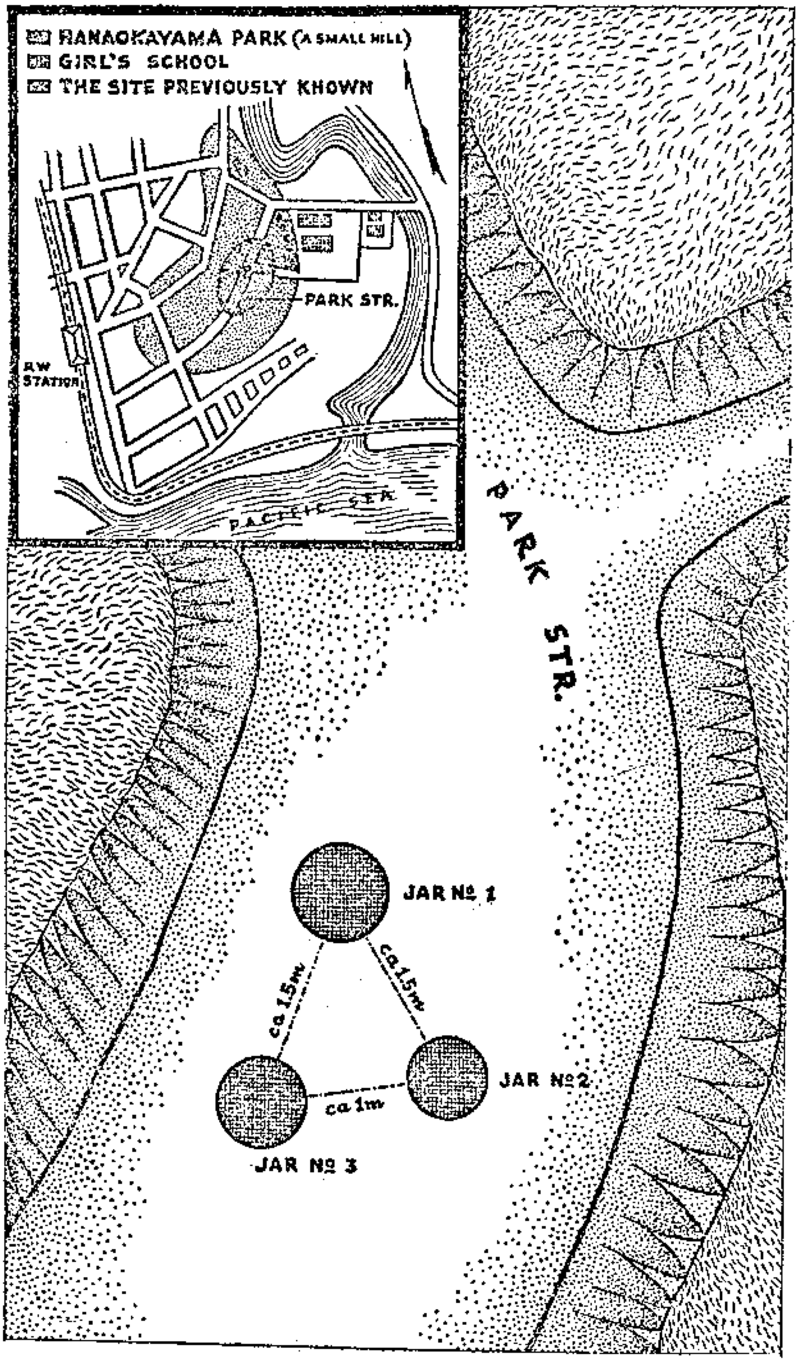

FIG. 4. Sketch map showing location of burial jars excavated in Karenko City, Taiwan.

spot in the Imourod village, located on the southern coast of the island. It is a large crudely baked earthen cylinder with round bottom, measuring 0.6 m in height and 0.6 m in width."

Another jar, from southern Formosa, containing a secondary burial of a child, was ". . . a finely baked reddish pottery with a corded pattern on the lower part of the vessel, measuring about 0.5 m in height and about 0.5 m in width."(10) A similar jar coffin was found at another site in the same prefecture.

From Samasana Island round-shaped urns occasionally containing human bones have been found in several places. The size of the urns is not certain. Besides bones, some contained ". . . round and white beads or long and green (or light blue) ones . . . The shapes are either melon-shaped or longish oval cylinders."(11)

In 1947 Professor Dr. Kanaseki and Mr. N. Kokubu discovered a burial jar site on the east coast of Formosa. Previously unpublished, a report of the discovery has been kindly sent me by Mr. Kokubu, which was followed in essence by Kanaseki's.

On June 12, 1947, Kanaseki and Kokubu, returning from an expedition to Botel-Tobago, stopped over at Karenko City (Hualien) for the night. That evening they were out for a walk in Hanaokayama Park (Huakangshan Park) in the city. Proceeding along a path near a previously known prehistoric site on the side of a hill, they noticed at the highest point on the hill (point x on the map, Fig. 4) three circles on the surface of the sandy path. Using stones to dig they found three earthenware jars placed almost vertically underneath. It was too late to return to the hotel to get tools before it became dark, and they had to leave early the next morning. They dug up the jars with their stone tools, making sketches of what they saw (Fig. 5). There were no skeletal remains found in the jars nor any associated artifacts. The bottoms of jars No. 1 and No. 2, and possibly No. 3, had been artificially perforated within the area of what was possibly a ring stand (Fig. 5, *a–b*).

As this site was near the prehistoric site at the Karenko Girl's School, Kanaseki included sketches of four stone artifacts from that site, in case they were sites of the same people (Fig. 6).

Ethnologically, burial in jars may still be practiced by the Kuvalan tribe, inhabitants of the plain of the northeastern part of Formosa.(9)

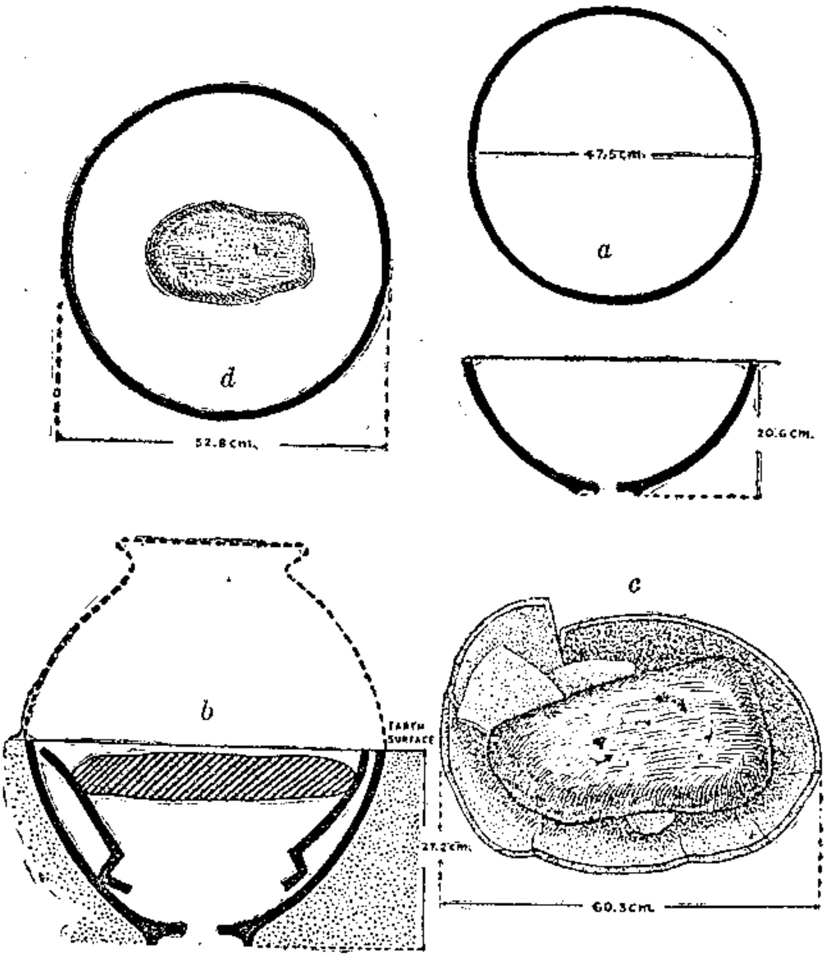

FIG. 5. Cross sections of burial jars *in situ* excavated in Karenko City, Taiwan.

Conclusion.—Based on the presence of burial jars in the Batanes and Babuyans, Kano(9) has stated ". . . it may be concluded that the relationship is another proof of the connection between Botel-Tobago and the Batanes Islands, and that the jar burying custom that originated in the Philippine Islands reached Botel-Tobago via the Batanes and Babuyanes Islands, and extended further north to Kashoto and the northeastern part of the Formosa mainland."

I do not feel that the scant data from Formosa are sufficient to demonstrate a close relationship. Two of the few specific facts from Formosa are melon-shaped and cylindrical green or light-blue glass beads, and jars with perforated bottoms and an apparent ring stand. Neither of these has as yet been observed from the Batanes or Babuyan Islands.

That there is some relationship is a reasonable assumption, but what it is cannot be arrived at from the present data.

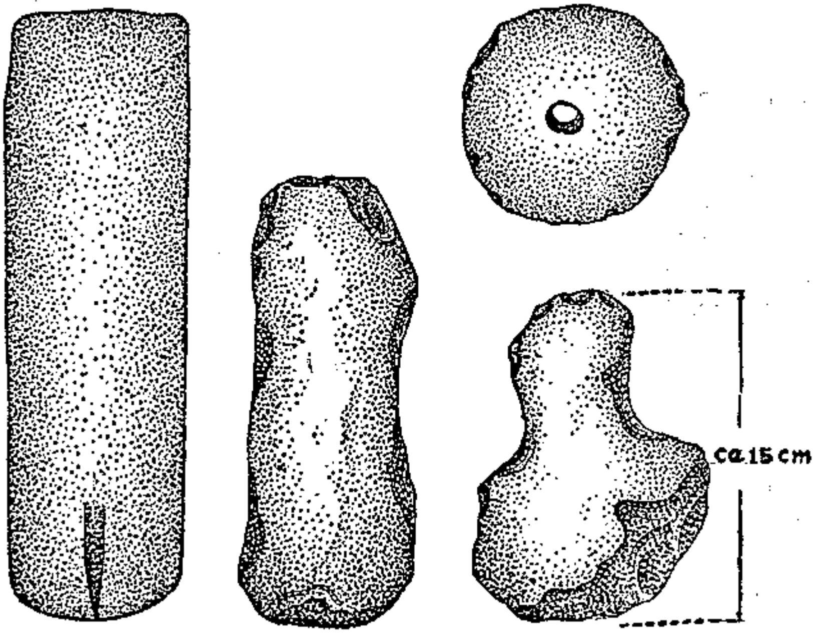

FIG. 6. Sketches of some stone tools from a site close to the burial-jar site in Karenko City, Taiwan.

JAPANESE JAR-BURIALS

The jar burials found in Japan have been briefly summarized by Mori.(14) The typical jar burials of the common type were used by people of the Yayoi culture. These burials were in two large earthenware jars, joined mouth to mouth and sealed by a clay ribbon (Plate 10, by Edward S. Kidder, Jr.). These were then placed horizontally in the ground or at an angle, apparently without a mound or cairn above.

Associated objects were rare. Those found were: "Bronze spears, bronze daggers, and bronze 'ko' halberds, all of Chinese origin. Bronze Chinese mirrors. (Types ranging from Former

Han Jewelry down to Later Han, including the intermediate Wang Mang epoch. (Beads of 'Magatama' . . . 'Kudatama' cylindrical beads, and small round beads, made of jade, nephrite, and glass . . .) Bracelets of shell, bronze, glass, and sometimes of iron . . . Swastika-shaped bronze objects . . . Iron daggers, iron 'ko' halberds, iron ax-heads. 'Pi' disc, with grain pattern, made of glass."(14) Most burials contain nothing.

These burials are found mainly in the northern part of Kyushu, particularly in the region facing the Strait of Korea and Ariake Bay. Cemeteries of these are commonly found associated with villages, and are always on the top of a hill or terrace.

A sequence of the jar burials has been presented.(14) First came large horizontally placed jars with small flat bottoms. Then large jars placed at an angle with a smaller jar or other type of lid. Finally, smaller vertical jars, less well-made, with rounded bottoms. The dating, by associated Chinese materials, goes from 200 B.C. to 500 A.D.

JAR-BURIAL IN INDONESIA

Van Heekeren has summarized the data on jar-burial sites in Indonesia.(7) "Our present knowledge proves that there are three or four different urn-burial customs in Indonesia, all belonging to the Early Metal Age. They can briefly be listed as follows:

c. Large urns in which human skeletons were interred singly in a squatted position; with them went polished dark-brown earthenware, saucer-shaped cups on stands, flasks with long vertical necks, and crude globular, round-bottomed pots. The decoration is simple and conventional. Example: Anjar, West Java.(8)

b. Large urns with skulls and some limb bones only, displaying a secondary burial system. Funeral gifts were specific earthenware, polished flasks with incised geometric patterns and human faces, the lines filled in with white paint, globular pots, shell rings, shell and stone beads and quadrangular stone adzes. Example, Melolo, East Sumba.(7)

c. Huge stone urns or vats. Similar to those of Laos, the latter definitely belong to the Early Metal Age. Example: Central Celebes.(15)

d. Large and small urns mostly of Chinese origin (1300 to 1600 A.D.), containing calcined human bones without funeral gifts. Prolonged until the coming of Islam. Numerous in the South Celebes (Bone, Soppeng, Wadjo)."

SUMMARY

In the Babuyan and the Batanes Islands, burial jars are found with or without stone cairns. There are usually two jars together in vertical position, one overlapping the other and acting as a lid. Where there are no cairns the jars are buried at least up to the rim of the bottom jar. The bottom jar may be of plain or red-slipped earthenware or imported stoneware. In all cases noted the lid was of earthenware jars usually have rounded bottoms.

In the Babuyans, besides some skeletal remains, the jars often contain paste, glass and stone beads, small stone disks, and bronze rings. In both the Babuyans and the Batanes there are occasional burial jars found with Chinese porcelain associated. In the Batanes, one jar was found with three adult flexed burials outside the jar.

Burial jars have been found only on the eastern side of Formosa and on small neighboring islands. No indications of cairns or mounds over the jars have been noted. Two jars from southern Formosa had a corded pattern on the bottom half. From another site in southern Formosa, three jars had perforated bottoms and possibly had ring stands. On Samasama Island a few beads were found inside some burial jars, the other jars discovered were empty.

In central Philippines there are two major varieties of jar burial. On the southeast coast of Luzon, early and late varieties of jar burial were found in caves, on the surface. With the earthenware jars in the early sites were associated stone and shell beads, other shell artifacts, and stone tools. The later sites had earthenware jars associated with Chinese porcelain and stoneware fragments of 15th to 16th century date, glass beads, and iron.

More centrally located are the subsurface sites, always in sight of the sea. There are no burial mounds of cairns over the large or small vertically buried jars. The large jars hold primary burials, while the small ones hold either children or secondary burials. Most of the jars have specially made stone covers. Associated are stone and shell tools, shell, paste and glass beads, and iron points and blades. Several of the sites have small earthenware vessels associated with each burial jar. However, other than at two neighboring sites on the Bondoc

Peninsula, this pottery differs greatly between sites. Two of the sites had associated extended burials not in jars.

Jar-burial sites in Japan are found in northern and western Kyushu and belong to the Yayoi culture. The jars are earthenware, usually with small flat bottoms. In the most common form of burial, the jars are joined mouth to mouth. The earlier burials had the jars placed horizontally. Later they began to place the jars at an angle, and in the last stages, smaller jars with rounded bottoms were placed vertically. The associated artifacts are often of Chinese origin ranging from Former Han down to Later Han.

Van Heekeren summarized four different jar-burial customs in Indonesia. The early sites had earthenware or stone jars placed vertically in the ground. Some of the earthenware jars were large, for primary burials, and some were smaller for use in secondary burials. Associated with the earthenware burial jars were small earthenware vessels, showing no resemblance to those found in the Philippines. The late sites had jars primarily of Chinese origin from about the 14th to the 17th centuries.

CONCLUSIONS

Great variation is found in the shape and size of the burial jars, in their position in the ground, with and without surface mounds, and in the associated artifacts, even within a small area. Obviously, some of this is the result of change in time, such as the change from earthenware jars to stoneware and porcelain. However, except where porcelain or other objects of Chinese origin of known date are present, the dating of these sites is very uncertain. There is no noticeable consistent change in space in any direction.

Within the total area covered, there are certainly subareas where the burials demonstrate sufficient consistency to be considered as belonging to single cultures. The best examples of this are Japan and the southeast coast of Luzon.

At the present stage of knowledge it would be preferable to treat the jar-burial custom as in isolated practice which may have diffused with or without migrations of people. Until we have much better control of the time factor for the early sites through more complete site reports, not only it unnecessarily complicates the problem, but probably is in error to think of the spread of the custom of burial in jars as the result of migrations of people. Much more than vaguely similar burial customs is needed to show migrations.

BIBLIOGRAPHY

1. BARTLETT, HARLEY HARRIS. Jar burials in the Babuyan Group, Philippine Islands, especially those of Dalupiri Island. Pap. Mich. Acad. Sci. Arts Lett. 23 (1937) 1–20.
2. BEAUCLAIR, INEZ DE. Personal letter from Taipei, Taiwan, dated February 26, 1959.
3. BEYER, H. OTLEY. Outline review of Philippine archaeology by islands and provinces. Philip. Jour. Sci. 77 (1947) 205–374.
4. FOX, ROBERT B., and ALFREDO EVANGELISTA. The Bato Caves, Sorsogon Province, Philippines; a preliminary report of a jar burial stone-tool assemblage. U.M. Journ. East Asiatic Stud. 6 (1957) 49–55.
5. FOX, ROBERT B., and ALFREDO EVANGELISTA. The cave archaeology of Cagraray Island, Albay Province, Philippines: a preliminary report of explorations and excavations. U.M. Jour. East Asiatic Stud. 6 (1957) 57–68.
6. GUTHE, CARL E. A burial site on the island of Samar, Philippine Islands. Pap. Mich. Acad. Sci. Arts Lett. 23 (1937) 31–32.
7. HEEKEREN, H. R. VAN. The urn cemetery at Melolo, East Sumba (Indonesia). Berita Dinas Purbakala (Bull. Archaeol. Ser. Rep. Indon.) 3 (1956) 1–24.
8. HEEKEREN, H. R. VAN. Note on a proto-historic urn-burial site at Anjar, Java. Anthrop. 51 (1956) 194–200.
9. KANO, TADAO. Burial jar found in the island of Botel-Tobago, with notes on the jar-burial custom of southeastern Asia. Zinruigaku Zassi (Jour. Anthrop. Soc. Nippon) 56 (1941) 134–135.
10. KOKUBU, NAIOCHI. Note on the burial customs in prehistoric Formosa. Proc. Fourth Far-Eastern Prehist. Eighth Pacific Sci. Cong. Part I (second Fascicle: Section 1) (1956) 309–318.
11. MABUCHI, TOICHI. Some oral traditions relating to urn-burial in Formosa, PFFEPEPSCC, Part I (Second Fascicle: Section 1) (1956) 319–328.
12. MANUEL, E. ARSENIO. Informe sobre las Islas Batanes (1775–1780). Philip. Soc. Sci. Human. Rev. 18 (1953) 99–123.
13. MILLER, MERTON L. The burial mounds of Camiguin Islands. Philip. Jour. Sci. 6 (1911) 1–6.
14. MORI, TEIJIRO. Archaeological study of jar-burials in eneolithic Japan, PFFEPEPSCC, Part I (Second Fascicle: Section 1) (1956) 225–245.
15. RAVAN, H. C. Huge stone jars of Central Celebes similar to those of northern Indo-China. Amer. Anthrop. 35 (1933) 545.

16. SOLHEIM, WILHELM G. II. Preliminary report of a jar-burial site in San Narciso, Tayabas, P.I. U.M. Jour. East Asiatic Stud. 1 (1951) 70–76.

17. SOLHEIM, WILHELM G. II. Philippine archaeology. Archaeology 6 (1953) 154–158.

18. SOLHEIM, WILHELM G. II. The Makabog burial-jar site. Philip. Jour. Sci. 83 (1954) 57–68.

ILLUSTRATIONS

[Line drawings by Manuel Santiago, Philippine National Museum; photographs by author.]

PLATE 1

Site 4 on Fuga Island: *a*, general view, with burial No. 6 in the center; *b*, closeup of burial No. 6.

PLATE 2

From site 5 on Fuga Island: *a*, burial jar *in situ* in coral cairn; *b*, small stoneware jar *in situ*; *c*, complete earthenware burial jar.

PLATE 3

Metal rings and stone and shell disk found inside burial jars on Fuga Island: *a* to *b*, from jar No. 10, Site 4; *c*, from jar No. 2, Site 3; *d*, from jar No. 2, Site 3; *e*, from jar No. 6, Site 4; *f* to *h*, from jar No. 12, Site 5.

PLATE 4

Burial jar from the Babuyan and Batanes Islands: *a*, earthenware jar, used for water storage, on Sabtang, Batanes Islands; *b*, glazed stoneware jar from Site 5, Fuga Island.

PLATE 5

Jar burial with three associated flexed burials near Basco, Batanes.

PLATE 6

Side and bottom views of a jar found on Sabtang, Batanes (left) and a recent copy made of this jar (right).

PLATE 7

Recudo (*a*) and Tumagudtud (*b* to *f*) Sites, San Narciso, Tayabas: *a*, inside bottom of jar with bone, metal, and shell artifacts; *b*, stone lid and small pots at level of the stone lid of a burial jar; *c*, burial jars, associated pottery and extended burial; *d*, extended burial with bolo along left arm; *e*, secondary burial; *f*, infant extended burial with associated small jar by left femur, foot bones of the other extended burial in foreground.

PLATE 8

Artifacts and burial from Tumagudtud, San Narciso: *a*, primary burial in a burial jar; *b*, small jar associated with extended burial; *c*, largest burial jar located; *d*, iron points and bolo associated with burials.

PLATE 9

Small pots from Tumagudtud, San Narciso: *a*, side and bottom view of a jar with a bright red slip and applique, perforated ring stand; *b*, jar with a bright red slip and applique ring stand; *c* and *f*, plain pots with high neck; *e*, incised pot; *d* and *g*, plain pots with high neck; *h*, globular pot.

PLATE 10

Jar burial from Iki Island, between Japan and Korea. Two wide-mouthed jars are shown joined rim to rim.

TEXT FIGURES

FIG. 1. Map of the Babuyan and Batanes Islands.

2. Cross sections of burial jars and lids from Fuga Island; *a*, lid from burial jar No. 6; *b*, rim of burial jar No. 6; *c*, burial jar No. 1; *d*, cover of burial jar No. 9.

3. Sketch map of Site 4, Fuga Island. The contour line on or near which most jars are situated roughly indicates the area of greatest erosion. The second contour line on the left is the top of a low knoll.

4. Sketch map showing location of burial jars excavated in Karenko City, Taiwan.

5. Cross sections of burial jars *in situ* excavated in Karenko City, Taiwan: *a*, jar No. 1; *b* and *c*, jar No. 2; *d*, jar No. 3.

6. Sketches of some stone tools from a site close to the burial-jar site in Karenko City, Taiwan.

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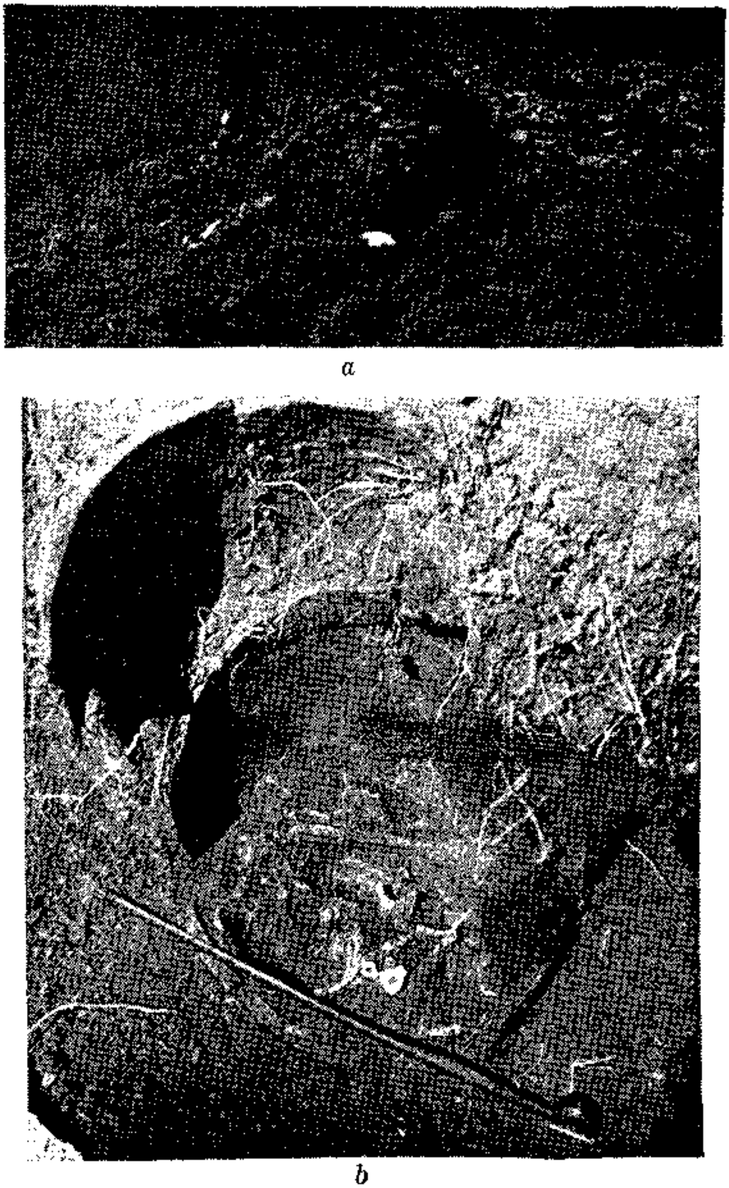

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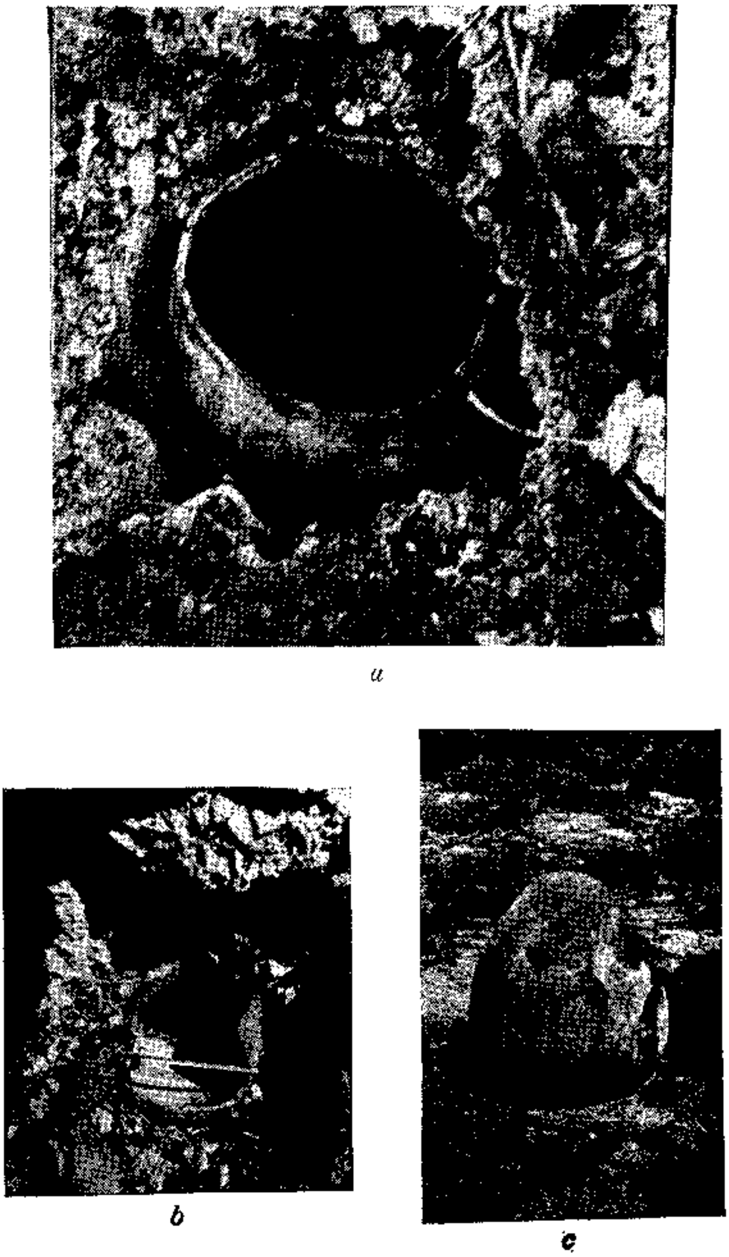

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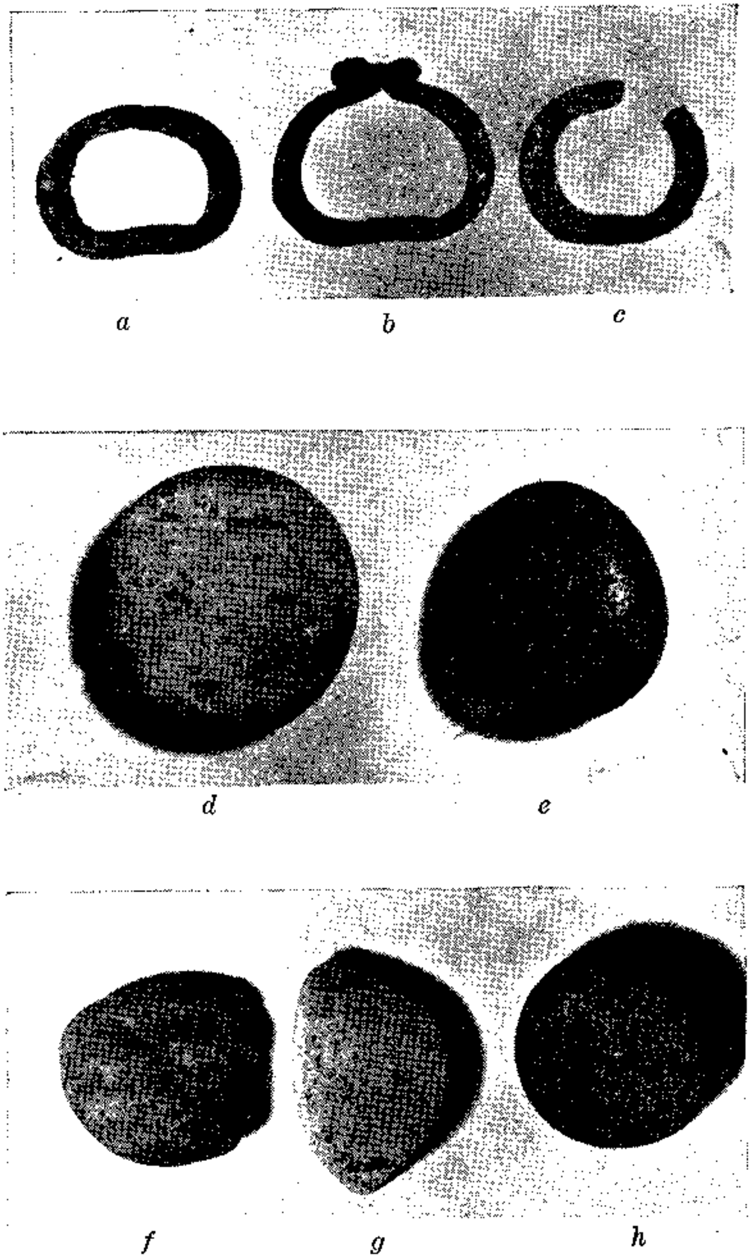

PLATE 3.

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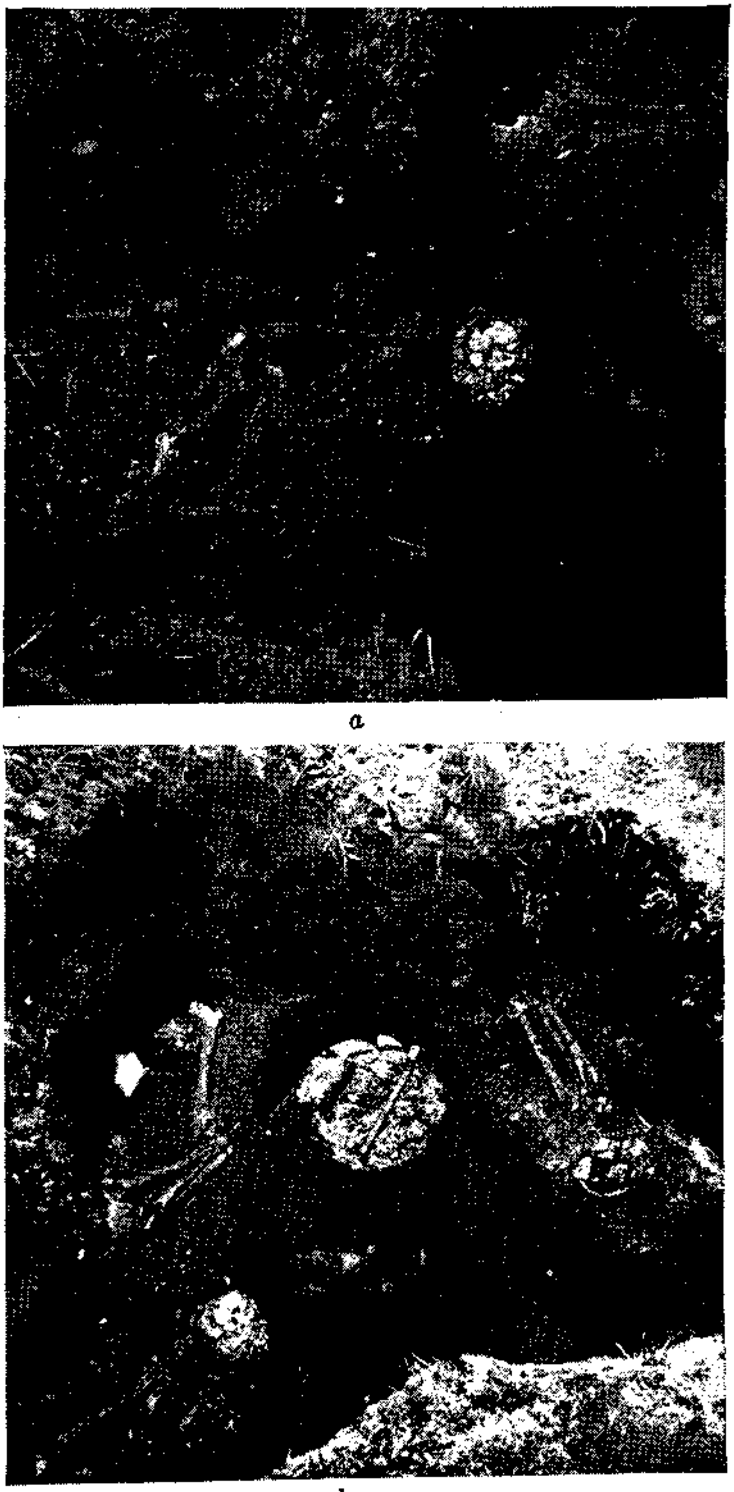
PLATE 4.



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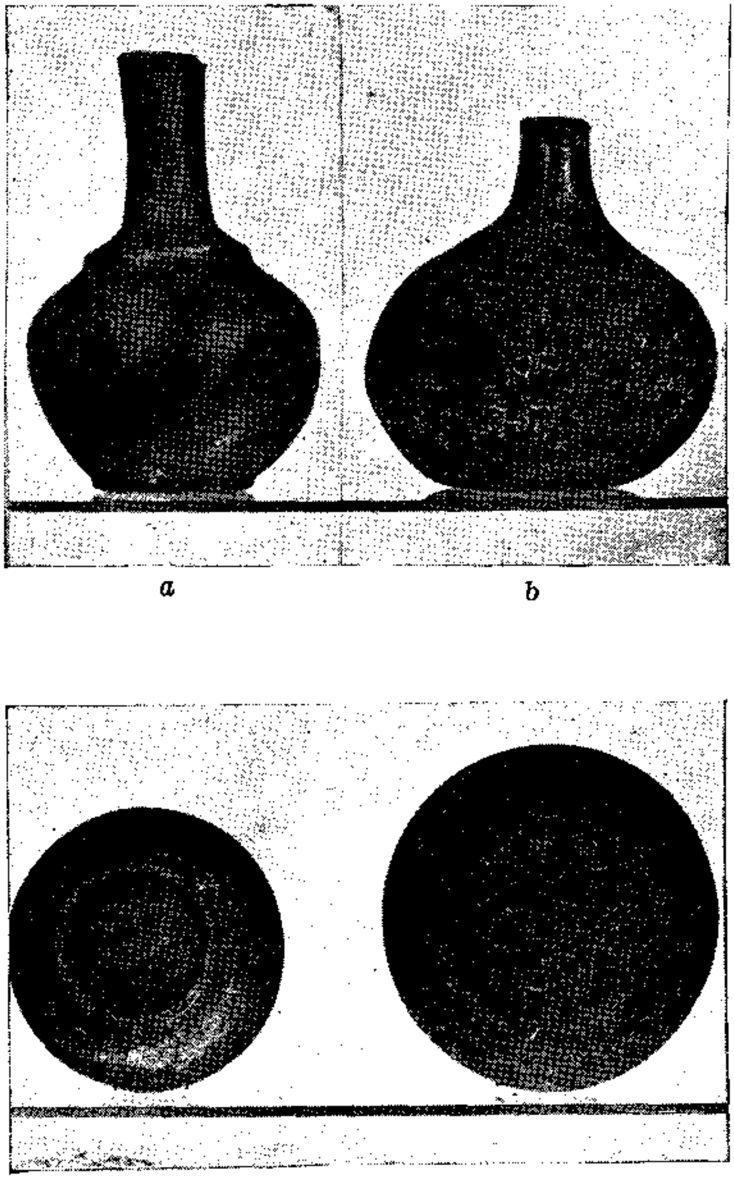

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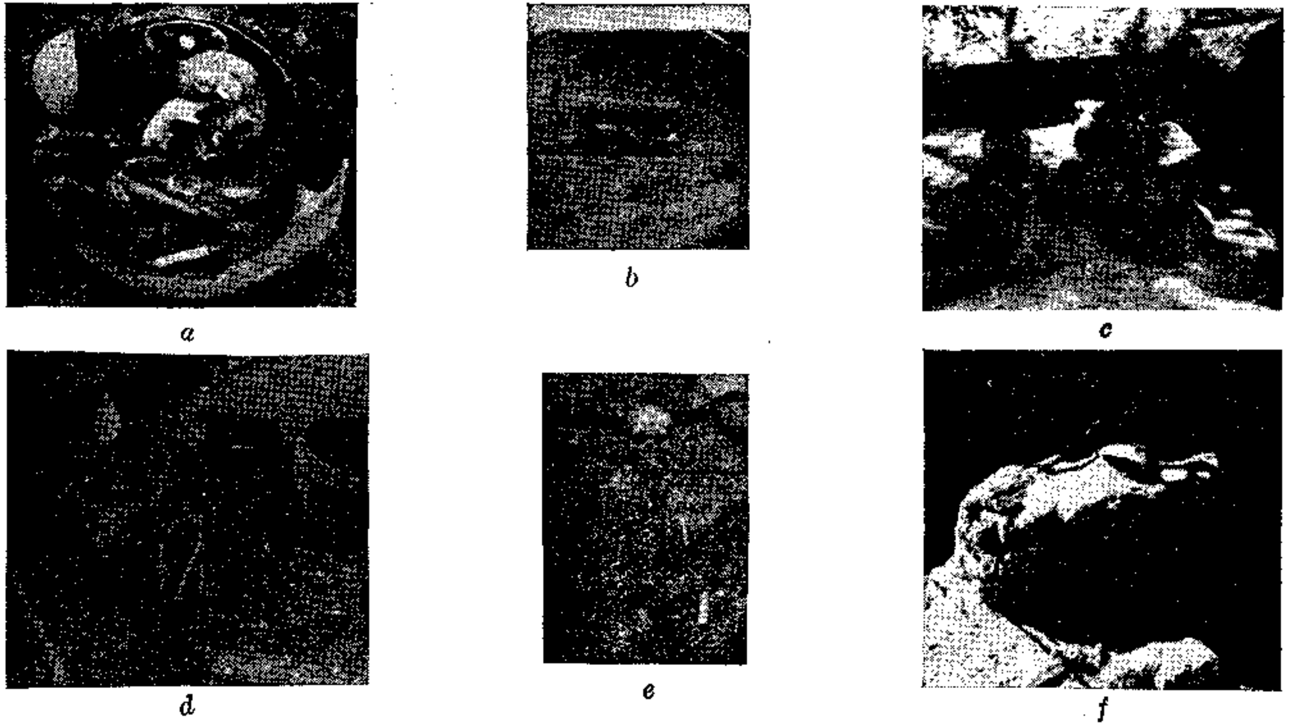

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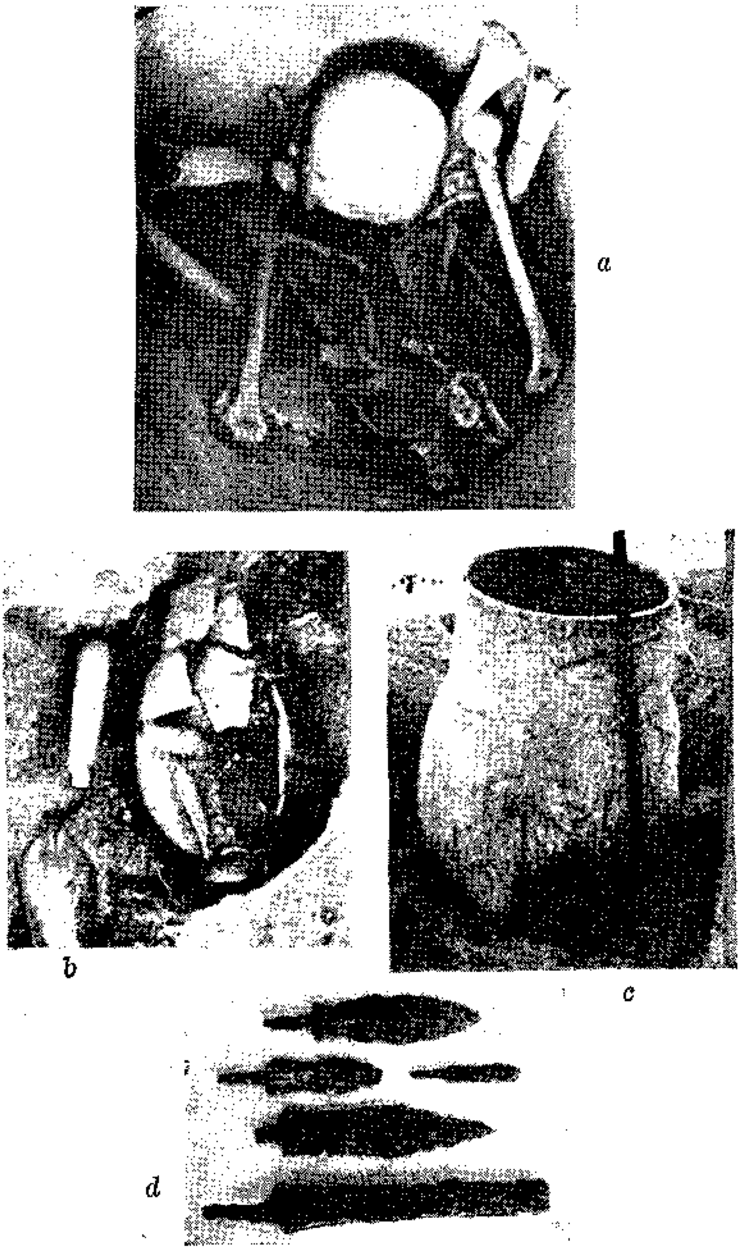

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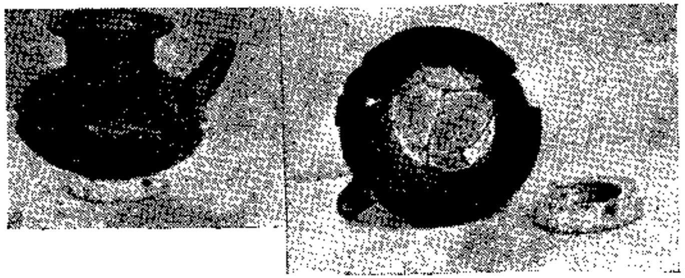
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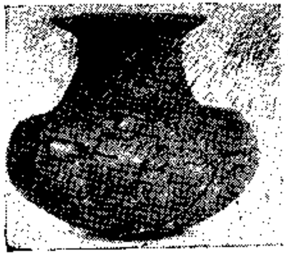
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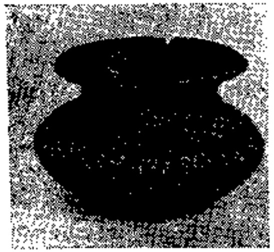
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PLATE 9.

PLATE 10.

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